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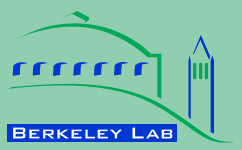

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Assessment of Energy Impact of Window Technologies for Commercial Buildings

Tianzhen Hong, Stephen Selkowitz, Mehry Yazdanian

Environmental Energy Technologies Division

October 2009

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Table of Contents

List of Figures

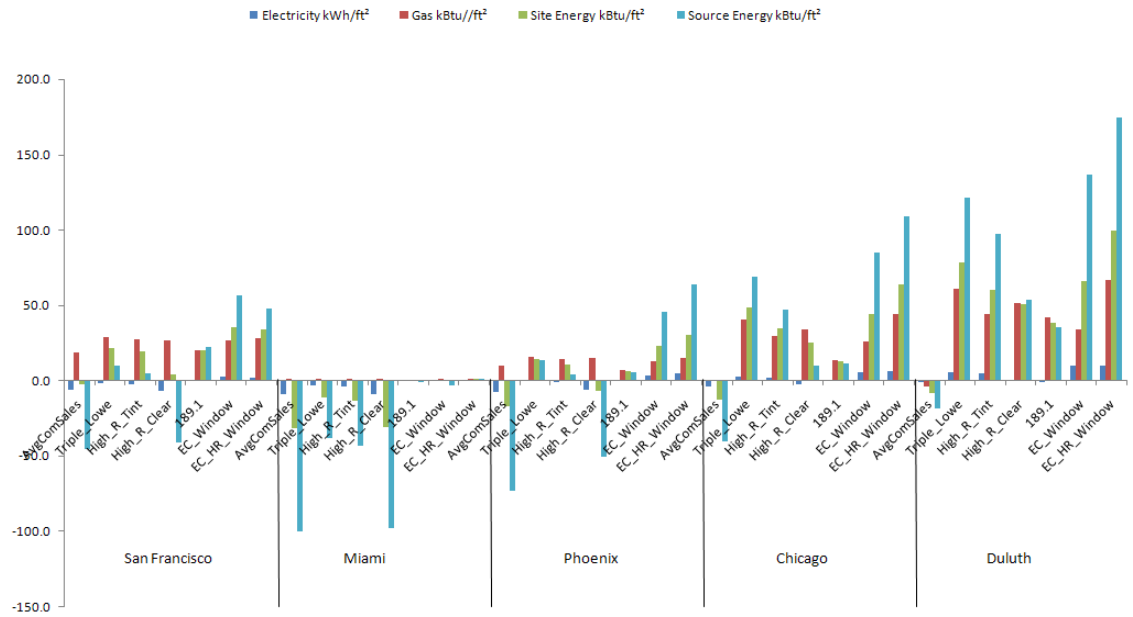
List of Tables

Executive Summary

Windows play a significant role in commercial buildings targeting the goal of net zero energy. This report summarizes research methodology and findings in evaluating the energy impact of windows technologies for commercial buildings. The large office prototypical building, chosen from the DOE commercial building benchmarks, was used as the baseline model which met the prescriptive requirements of ASHRAE Standard 90.1-2004. The building simulations were performed with EnergyPlus and TMY3 weather data for five typical US climates to calculate the energy savings potentials of six windows technologies when compared with the ASHRAE 90.1-2004 baseline windows. The six windows cover existing, new, and emerging technologies, including ASHRAE 189.1 baseline windows, triple pane low-e windows, clear and tinted double pane highly insulating low-e windows, electrochromic (EC) windows, and highly insulating EC windows representing the hypothetically feasible optimum windows. The existing stocks based on average commercial windows sales are included in the analysis for benchmarking purposes.

A comprehensive set of performance metrics were used to represent the performance of windows on the whole building basis as well as the perimeter zone basis with different orientations. Life cycle cost analysis is beyond the scope of the project. Daylighting benefit with typical shading controls was evaluated. Sensitivity analysis was also conducted to evaluate the impact of key factors, including daylighting controls, shading controls, window area, and internal loads, on energy performance of windows.

The following figure shows the energy savings per square foot of window area for the seven windows compared with the ASHRAE 90.1-2004 baseline windows when daylighting controls are not installed.



Energy Savings per Square Foot of Window Area, No Daylighting Scenarios

By windows technologies,

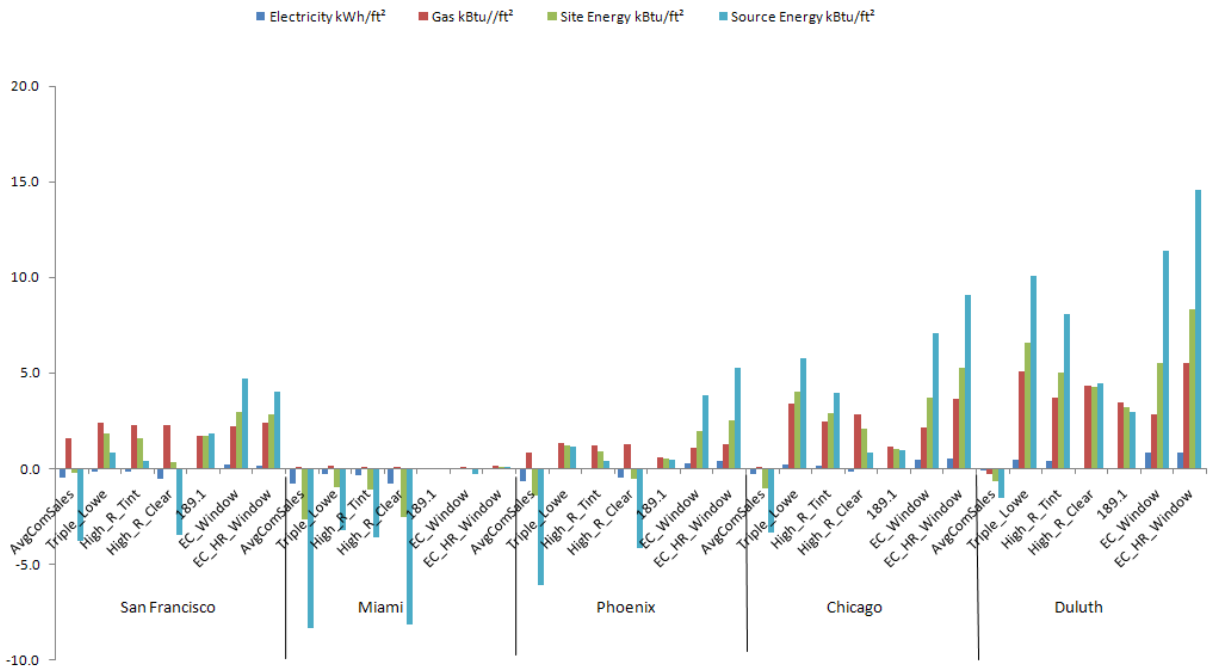
- The existing commercial windows consumed more energy than the 90.1-2004 baseline windows across all five climates. All six windows technologies save heating energy compared with 90.1-2004 windows: savings are much higher in cold climates.
- The two EC windows show the best energy savings potentials followed by the triple pane low-e windows, the tinted and clear double pane highly insulating low-e windows, and the 189.1 windows.
- The highly insulated EC windows demonstrate the best energy performance for Duluth, Chicago, and Phoenix; while for San Francisco, the normal EC windows are the most energy efficient.
- The Triple low-e windows show better energy performance in cold climates such as Duluth and Chicago, while they are still more energy efficient than the 90.1-2004 windows in other climates such as San Francisco and Phoenix.
- The ASHRAE 189.1 baseline windows show better energy performance than the 90.1-2004 windows in Duluth and San Francisco, while savings are marginal in Phoenix and Chicago.
- The two highly insulating windows only show better energy performance than 90.1-2004 windows in cold climates such as Duluth and Chicago.

By climate zones,

- For Miami where cooling is dominated and heating is almost not required, none of the seven windows technologies demonstrate site or source energy savings. This probably due to the low SHGC and high U-factor of the 90.1-2004 windows for Miami.
- For mild climate such as San Francisco, the EC windows save the greatest source energy, followed by the high-R EC windows and the 189.1 windows.
- For hot and dry climate such as Phoenix, the two EC windows save most energy, followed by the triple low-e windows which are marginally better than the 90.1-2004 windows.
- For cold climate such as Duluth and Chicago, the two EC windows save most energy, followed by the triple low-e windows and the double tinted high-R low-e windows.
- In general, windows with low U-factor (better insulating performance) demonstrate the greatest energy savings potentials except for cooling dominated climate such as Miami.

Daylighting energy savings are significant when comparing daylighting cases with no daylighting cases for same types of windows. On the basis of per square foot of window area, the electricity savings range from 8.2 kWh/ft² in San Francisco to 9.8 kWh/ft² in Miami; the site energy savings range from 14.5 kBtu/ft² for the EC windows in Duluth to 33.3 kBtu/ft² for the double clear high-R low-e windows in Miami; while the source energy savings range from 76.7 kBtu/ft² for the EC windows in Duluth to 103.3 kBtu/ft² for the double clear high-R low-e windows in Miami. On the whole building electricity use basis, the daylighting saves from 5% of the 90.1-2004 windows in Phoenix to 7% of the high-R EC windows in Duluth; while on the whole building source energy basis, the daylighting savings are from 4.7% of the 90.1-2004 windows in Phoenix to 6.2% of the double high-R clear windows in San Francisco.

The following figure shows the energy savings calculated by per square foot of building floor area for the seven windows compared with the ASHRAE 90.1-2004 baseline windows when daylighting controls are not installed. Considering the ASHRAE Standard 90.1-2010 target of site energy 33.3 kBtu/ft² and the 2003 CBECS national average commercial buildings site energy usage of 91 kBtu/ft², the energy savings potentials of windows technologies are significant especially for EC windows (except for Miami) and high-R windows in cold climates.



Energy Savings per Square Foot of Building Floor Area, No Daylighting Scenarios

Introduction

Windows are an essential part of buildings. Windows not only provides view and connection with outdoor for building occupants, but also transfer heat and solar gains into the building. Windows have significant impacts on a building's energy usage, as they contribute to a building's heating and cooling loads as well as lighting if daylighting sensors and controls are deployed. Windows in the U.S. consume 30% of building heating and cooling energy, representing an annual impact of 4.1 quadrillion BTU (quads) of primary energy. Windows have an even larger impact on peak energy demand and on occupant comfort. An additional 1 quad of lighting energy could be saved if buildings employed effective daylighting strategies.

Despite past progress in window technology, windows are still a huge liability in terms of energy consumption. With the deployment of advanced windows technology, windows have the technical potential to reduce this energy use to zero – thus supporting DOE's vision of net zero energy buildings (ZEB) for commercial sector in 2030.

The goal of the study is to determine the technical potential of advanced windows technologies in terms of energy impacts for large office buildings in the US. The study would also help define a preliminary technology baseline on which to base future studies of the performance potentials of window technologies or other related technical options. This study is intended to establish relatively fundamental trends which would be expected to hold up under more detailed investigations. This study can also form the basis for more intensive or comprehensive analyses, such as those appropriate for research to optimize technologies, to design experiments for testing technologies, and as a basis for design guidance and design optimization for practice.

Overview of Commercial Building Characterization

According to EIA 2006 Commercial Building Energy Consumption Survey (CBECS), there were 4.9 million commercial buildings in the U.S. which covered 72 billion square foot of floor space in 2003 – an increase of 28% in number of buildings and a 40% increase in floor space since 1979. By 2030, commercial building floor space is expected to reach 108 billion square foot – a 51% increase over current levels (EIA 2007 Annual Energy Outlook).

Commercial buildings in the U.S. consumed 5.8 quads of site energy in 2003 according to the EIA 2006 CBECS. That is about 18% of the total energy used in the U.S. (Figure 1, EIA Annual Energy Review 2006), and about 64% increase over 1980 levels (2006 Buildings Energy Data Book).

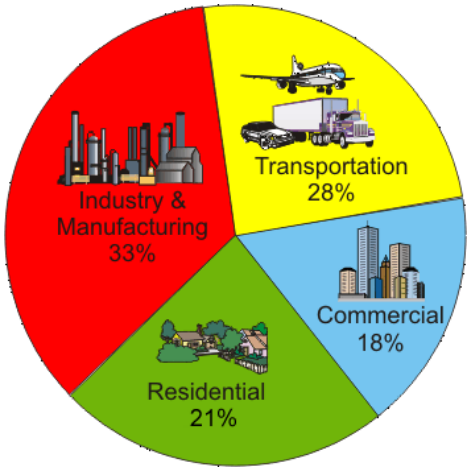


Figure 1 - Share of Energy Consumed by Major Sectors of the US Economy

According to the 2007 Buildings Energy Data Book, among all types of commercial buildings, retail and service buildings use the most energy. Offices use a large share of energy, too. Education buildings use 13% of all total energy! Lodging buildings use 8% of all energy. Warehouses and food service each use 7%. Public assembly buildings, which can be anything from libraries to sports arenas, use 6%; food sales buildings use 4%. All other types of buildings, like places of worship, fire stations, police stations, and laboratories, account for the remaining 10% of commercial building energy.

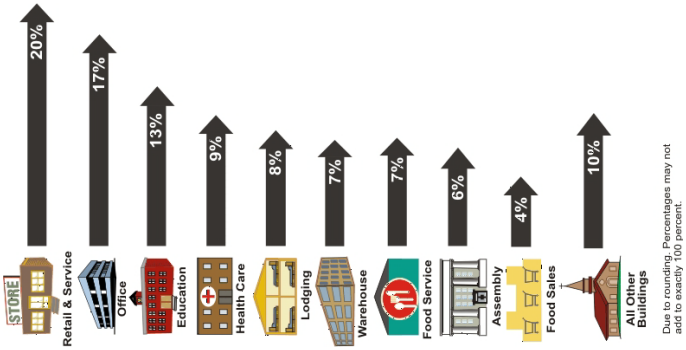


Figure 2 - Energy Use in Commercial Buildings by Building Types

The nationwide energy consumption of commercial buildings is predicted to continue grow due to the increase of the total floor area of commercial buildings, even though the average Energy Usage Intensity (EUI) of commercial buildings showed a decrease by 21% between 1979 and 2003, from 115 kBtu/sf to 91 kBtu/sf (EIA 2007, Annual Energy Review 2006). Among all energy end uses of commercial buildings in 2005, space heating, space cooling, and lighting together (53%) consume more than half of the energy in commercial buildings (Figure 3, 2007 Buildings Energy Data Book).

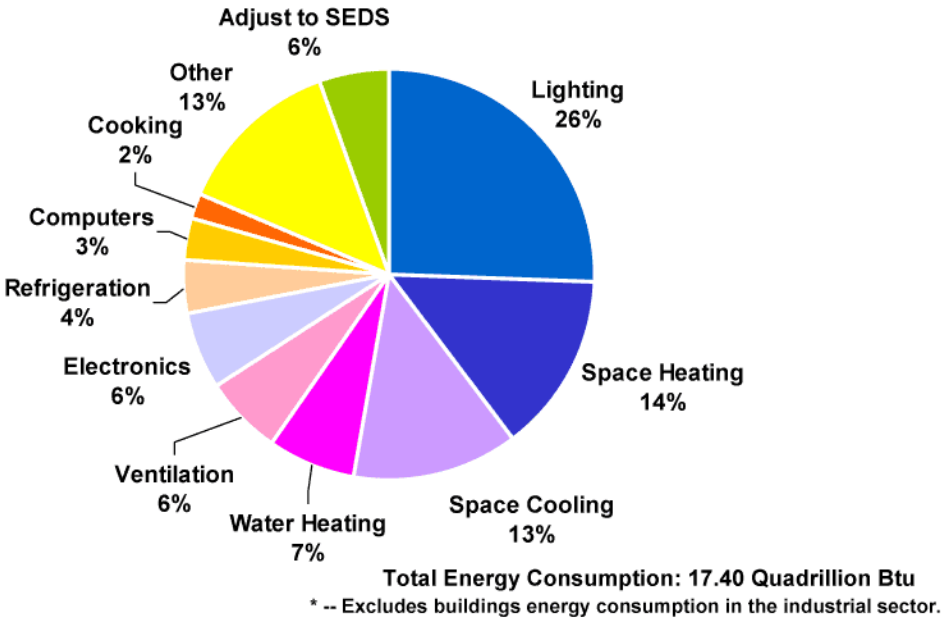


Figure 3 – US Buildings Energy End-Use in 2005

*SEDS is an energy adjustment used by EIA to relieve discrepancies between data sources

The selection of windows in commercial buildings has an enormous impact on space heating and cooling loads and directly impacts the need for electric lighting. Look at breakdowns of component loads (2007 Buildings Energy Data Book) for space cooling and space heating in commercial buildings (Figure 4 and Figure 5), window (heat conduction), solar, lighting, and infiltration (air leakage) are directly related to windows.

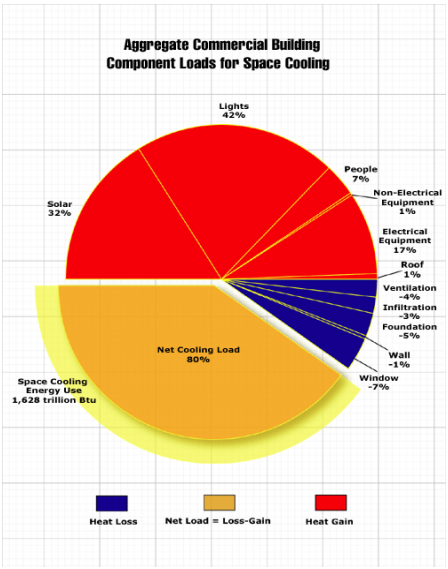


Figure 4 - Aggregate Commercial Building Component Loads for Space Cooling

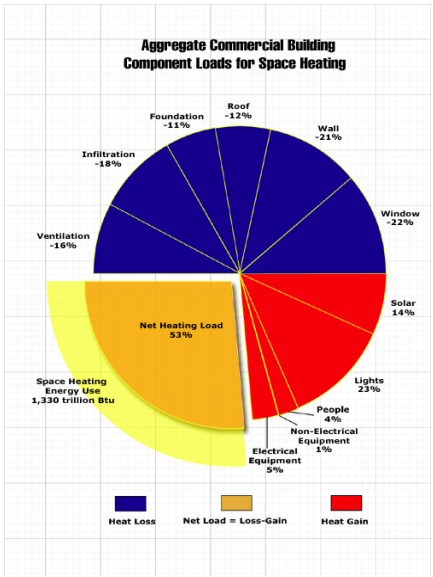


Figure 5 - Aggregate Commercial Building Component Loads for Space Heating

Windows today collectively use more than 4 quads of energy per year and contribute to carbon emissions that cause global climate change. The commercial window sector represents about 30 to 40% of all window sales today in terms of glass area. About half of these windows are sold for new constructions and half for replacement windows in existing buildings.

Overview of Window Technologies

The main function of windows in the building envelope has evolved significantly since their advent as simple holes for exhausting smoke and letting light in. Windows now function not only for the comfort of building occupants but also as a high-tech barrier layer that reduces heat transfer into or out of

buildings. In 1973, the typical window in most U.S. buildings was a single pane clear window. At the turn of the 21st century, the typical window is now double pane with low-E coating.

Fenestration sales in the commercial sector are shown in Table 1 (DOE MYP 2008-2012). The market has largely shifted to double-pane products; triple-pane products are still only a tiny fraction (2 to 3%) of the total. Low-E has only half the penetration in this sector that it has in the residential sector, with reflective and tinted glass making up 26% of the sales, reflecting a concern for managing cooling loads.

Table 1 - Profile of Commercial Window Sales

Window Type	Percent of Sales	U-factor Btu/(hr-ft^2-^{o}F)	SHGC
Single Pane, Clear Glass	11%	1.16	0.74
Double Pane, Clear Glass	30%	0.62	0.63
Double Pane, Tinted Glass	6%	0.65	0.13
Double Pane, Reflective Glass	20%	0.62	0.46
Double Pane, Low-e Glass	30%	0.51	0.34
Triple Pane, Low-e Glass	3%	0.51	0.34
Average Properties	100%	0.65	0.48

Future development of windows technology focuses on: 1) high insulating windows with low-e coating that can significantly reduce windows heat transfer, 2) dynamic windows with automatic switchable glazings to maximize benefits of solar heat gains and daylight view, 3) airflow windows with natural ventilation capability that provide free cooling and improve indoor air quality, and 4) smart/dynamic facades integrated with the building's automatic energy and management control systems to maximize cooling, heating, and daylighting benefits.

Low-e Coating

The commercial trend is moving away from tinted and reflective to clear low-E or spectrally selective low-E. There are several types of low-E coatings, and they can be applied to any glass substrate. Adding gas fills and warm-edge spacers creates an enormous range of product configurations. Double pane glass with low-e coatings are the baseline Energy Star windows for residential buildings. Building energy standards like ASHRAE 90.1-2001 and later and California Title 24-2001 and later require minimum of double pane low-e windows for most climate zones.

Framing Systems

Market shares of framing systems are driven by building type and location. For example, wood windows are used in many low-rise buildings such as schools whereas large office buildings normally have an aluminum curtain wall. Metal frames continue to be the major choice in larger buildings where structural issues are more important. The thermal performance of the metal extrusions can be improved using thermal breaks in the frame.

When high-R glazing systems are used in typical residential window frames, about half of the heat loss through the entire window is through the frame. Even with today's best window frames, heat-transfer

rates through frames are two to three times the rates through the glazing. Improving the heat transfer of a frame system is difficult because frames must perform so many functions: in addition to being structural components, they must be weather resistant, operational, and durable. Industry efforts to reduce frame heat transfer have focused on incremental improvements to existing technologies (i.e., redesigning vinyl frames to increase air-cavity resistance, develop high-performance commercial aluminum framing). Future research aims to investigate pathways for reduced frame heat transfer (e.g., eliminate 3-D convection, reduce radiation in cavities). High-R glazings and framing have an important role to play in commercial buildings because people often work in proximity to glazing, so occupant comfort can be a major issue.

Shades and Controls

Dynamic shading control can be provided today via numerous shade and blind systems that are currently available from many manufacturers at a wide range of price points. These systems can be manually operated or motorized and automated. What drive these systems are the "intelligence" control algorithms that need further research and field testing. Although conventional motorized shades and blind systems have advantages and disadvantages relative to electrochromic windows, they have the potential advantage of being able to block direct sun, which is important for visual and thermal comfort, and of redirecting sunlight, also important for visual comfort and daylighting.

"Off-the-shelf" commercially available shading systems that five years ago simply implemented solar control ("block direct sunlight") are now claiming more sophisticated algorithms ("improve daylight utilization," "reduce glare," etc.) in part because of the competitive marketplace generated by the *New York Times* building and other projects. More sophisticated systems can and have been tailored for higher-end applications (e.g., primarily automated shades for winter heat gain/ summer heat rejection strategies needed for European double-envelope façade applications).

An emerging market in shades is dynamic shades with the capability to redirect portion of direct sun light into the space. Redirecting shades can maximize daylight view and savings of electric lighting energy use.

Daylighting and Controls

Daylighting coupled with effective lighting controls can cut electric lighting energy by half for perimeter zones. Furthermore, most occupants prefer daylight because it is associated with view, connection to the outdoors, and good illumination quality. The challenge posed by daylight is two-fold: to introduce it through the glazing in a manner that provides relatively uniform indoor light levels without excessive solar gain and glare, and to dim or turn off the electric lighting so that energy is saved. Although the latter requirement is an electric lighting system issue, the first directly relates to glazing, framing, and shading system elements, which may be fixed or dynamic. The fenestration system is part of the building design, form, shape, interior, landscape, and other elements that all influence the overall impact that daylighting may have in a building. The potentials are very large, but so far the achieved savings are modest because specific technologies for light and glare management are lacking, as are the tools and

experience to achieve the complex integration and optimization of building systems that is necessary for successful employment of daylighting. Some of the best and most effective applications today are toplight designs using skylights and light tubes. Interest and activity remain high, particularly because the savings potentials remain large, and daylighting is being emphasized in the currently popular green building design movement. Research also extends to developing a better understanding of user needs and preferences in daylit offices as this underlies the development of sensors, controls and operating algorithms needed to capture the energy savings.

Smart Facades

Commercial buildings with smart facades that can minimize thermal gains and losses while capture the energy benefits of daylighting would help buildings save more energy than buildings with opaque insulated façades. The unique and innovative aspect of smart façade technologies is the dynamic response empowered with intelligence to optimize daylighting, prevent discomfort glare, minimize cooling loads, and maximize view. Smart facades coupled with downsized low energy cooling and lighting systems can be crucial for ZEB goal.

Highly Insulating Windows

Despite the technical and market success of low-E windows, the single largest window energy end use is heat loss. To reduce this loss, development of windows reaching insulation levels of R10 has been the subject of research around the world for several decades. Current technologies for high-R products use multiple layers of glass with low-E coatings and gas fills, or a thin stretched plastic film in the center of the glass unit. The drawbacks to these approaches are that the amount of glass used makes window units heavy, the thin film products reduce the weight but are expensive, and the installation of multiple spacers increases costs and can lead to gas leakage. DOE Windows research aims to develop novel lower-cost, nonstructural center layers that utilize available low-e and gas-fill technologies.

High-R windows depend on three key areas: 1) high-R glazings, 2) high-R framing, and 3) systems integration and field demonstration of complete window systems solutions. Aerogel can be used as the insulating material between glass panels. Vacuum glazings offer theoretically high center-of-glass performance, but total window performance is compromised by structural spacers used to keep the glass layers apart, edge short-circuiting, and the lack of low-E coatings that can sustain high temperatures of the edge-welding process. Structural issues (stress and glazing integrity) are also of concern. Vacuum glazing is now commercially available in Japan from Nippon Sheet Glass but with insulating values of only 0.25 Btu/hr-ft2-F, which falls well short of the necessary performance for ZEBs.

Prior studies demonstrated that a three-layer, low-E, gas-filled glazing unit might reach R10 insulating values and could fairly readily achieve R6-R8. In principle, a conventional triple-glazed unit could do this, but the weight of the unit and the additional seals required would make it difficult to market. Currently there are research focusing on developing alternative center glazing layers (heat mirror, triple-glazed units) for multiple low- E/gas-filled units that would overcome the labor, weight, and structural issues associated with current triple-glazed products.

Dynamic Windows

Dynamic windows can offer advantages of bringing adequate daylight and view, limiting solar heat gains in cooling seasons, and maximizing solar heat gains in heating seasons. Pilot projects with electrochromic windows were technically successful, but it will take a number of years for significant market penetration of that technology because costs remain high, size is limited, and the technology can be obtained only from a small number of sources. However, these products are expected to mature in the next 5 to 10 years as major manufacturers are developing a reliable intermediate state controller and mass production cost will be significantly reduced.

Airflow Windows

Airflow windows are windows with operable capability that can provide natural ventilation for free cooling and improve indoor air quality for occupants. These windows are controlled by a complex algorithm probably embedded in the building automation systems to determine when to open and close the windows based on indoor and outdoor temperature and humidity conditions and operating status (in cooling or heating mode) of HVAC systems.

Simulation Tools

A suite of computer tools (Window, Optics, Therm, RESFEN, COMFEN) have been developed at LBNL to simulate the thermal and optical performance of windows in residential and commercial buildings. These tools also form the technical foundation of windows labeling systems for NFRC. DOE-2 has been the most popular computer tool to simulate the energy performance of the whole buildings including building envelope, lighting, daylighting, water heating, and HVAC systems. EnergyPlus is the new generation tool that offers modeling features beyond DOE-2, especially for integrated performance of innovative building components and HVAC systems and control strategies. The windows modeling approach has been evolving from using overall fixed properties of U-factor and SHGC to layer-by-layer definitions with angular optical properties for average spectral data to angular optical properties for detailed spectral data.

The International Glazing Database (IGDB) provides optical data for glazing products used by Window and Optics including NFRC approved products. The Complex Glazings Database (CGDB), under development, includes data on complex non-specular glazing layers. Such layers include diffusing glass products such as patterned or fritted glass and shading layers such as Venetian blinds and woven shades. Because complex layers do have angular properties that follow the simple pattern of conventional glass (clear, tinted, or coated), the data requirements to describe optical and thermal performance are much more involved than is required in the IGDB. The CGDB is used in WINDOW version 6, which is the first version of WINDOW to handle complex layers.

Overview of Prior Studies

Most prior windows studies for the commercial sector focused on specific window technologies for specific building types located in specific climate zones. Most old studies used DOE-2.1E as the analysis tool while more recent studies used EnergyPlus. Table 2 summarizes several studies done by LBNL and NREL during 2002 to 2007.

Table 2 – Summary of A Few Prior Studies

Report Title	Authors	Reference	Year Study Done	Buildings and Locations	Windows Studied	Simulation Tool	Performance Metrics	Main Findings
Energy performance analysis of electrochromic windows in New York commercial office buildings	E. S. Lee, L. Zhou, M.Yazdanian, V. Inkarojrit, J. Slack, M.Rubin, S.E. Selkowitz	LBNL-50096	2002	Prototype new and old small and large office buildings in New York city or Buffalo. Window-wall-ratio varies from 0 to 60%	Electrochromic windows with daylighting controls compared with 5 commercial windows with and without interior shades	DOE-2.1E	Energy performance data are given for each of the four perimeter zones. Data are presented as a function of window-to-wall ratio to better understand the interactions between 1) electric lighting energy use and daylight admission and 2) solar heat gains and space-conditioning energy use. Maximum and minimum reductions in energy use between the EC glazing and all other base case conditions are also presented.	The energy and demand reductions provided by EC glazings with daylighting controls relative to what is typically specified in office buildings in NY are quite substantial. EC glazings would also dampen fluctuations in interior daylight levels and window brightness, potentially increasing visual comfort
The energy savings potential of electrochromic windows in the US commercial buildings sector	E.S. Lee, M. Yazdanian, S.E. Selkowitz	LBNL-54966	2004	A three-storey prototypical office building located in 5 US climates and 16 California climate zones	Electrochromic windows controlled to maintain daylight illuminance setpoint is compared to conventional and the best available commercial windows as well as baseline windows	DOE-2.1E	Perimeter zone energy use and peak demand savings data by orientation, window size, and climate are given for windows with interior shading, attached shading, and horizon obstructions.	Perimeter zone primary energy use is reduced by 10-20% in east, south, and west zones in most climates if the commercial building has a large window-to-wall area ratio of 0.60 compared to a spectrally selective low-e window with daylighting controls and no interior or exterior shading. Peak demand for the same condition is reduced by 20-30%. The emerging electrochromic window with daylighting controls is

					defined by the ASHRAE 90.1-1999 and California Title 24-2005			projected to save approximately 91.5-97.3 1012 Btu in the year 2030 compared to a spectrally selective low-E window with manually-controlled interior shades and no daylighting controls if it reaches a 40% market penetration level in that year.
Zero energy windows	D. Arasteh, S. Selkowitz, J. Apte, M. LaFrance	LBNL-60049	2006	Residential and commercial buildings	Average sales and 5 window technologies: low-e, dynamic low-e, triple pane low-e, high-R dynamic, and integrated facades.	DOE-2.1E	Annual energy savings in cooling, heating, and lighting.	Try to define the requirements for zero-energy windows. Full adoption of low-e technology would save 0.4 to 0.5 quads over sales. Both triple pane low-e and dynamic low-e product scenarios offer substantially larger energy savings than what would be possible with low-e products. Either scenario offers potential energy savings of approximately 0.8 quads over sales. Dynamic low-e products appear particularly promising, as they offer peak demand reductions. Adding dynamic solar heat gain control to the High-R Superwindow technology scenario dramatically improves cooling season energy performance. This scenario offers energy savings of about 1.4 quads over the business as usual case.
Window-related energy consumption in the US residential and commercial building stock	J. Apte, D. Arasteh	LBNL-60146	2006	Residential and commercial buildings	Existing stock and 5 commercial window technologies: average sales, low-e, dynamic low-e, triple pane low-e, and high-R	Data Analysis based on existing DOE-2.1E runs. Also use in-house	Estimate windows related energy consumption for both the residential and commercial buildings in the US based on calculated window fraction of total HVAC energy consumption by 2005 DOE Buildings	Windows are responsible for 2.15 quadrillion Btu (Quads) of heating energy consumption and 1.48 Quads of cooling energy consumption annually. A complete replacement of the installed window stock with these products would result in energy savings of

					dynamic windows	Spreadsheets.	Energy Databook.	approximately 1.2 quads. Future window technologies offer energy savings potentials of up to 3.9 Quads.
Evaluating fenestration products for zero-energy buildings: issues for discussion	D. Arasteh, C. Curcija, J. Huang, C. Huizenga, C. Kohler	LBNL-61249	2006	Residential and commercial sectors.	Highly insulating, dynamic, complex facades, low-SHGC, non-specular, daylighting and solar control.	All windows tools	Window properties representing window thermal and optical performance under different conditions.	Discussed issues and solutions to windows for ZEB including. Recommended improvements to window tools, especially their link with whole building energy simulation tools like EnergyPlus.
Analysis of window energy savings in commercial buildings in the Pacific Northwest	J. Huang, M. Yazdanian	LBNL-60379	2007	Large and small office prototypes in two locations (Seattle, Boise), with two vintage variations (Old and New), three lighting power densities (0.8, 1.0, and 1.2 W/ft2).	146 variations of window U-value, Solar Heat Gain Coefficient (SHGC), and drapery shading condition.	DOE-2.1E	Building energy usage by different end-uses, i.e., heating, cooling, cooling tower, fans, pumps, lighting, and service hot water, and the differences in energy use for changes in window U-factor and SHGC	Estimate energy performance and savings potential for different window products in the commercial buildings in the Pacific Northwest.
Assessment of building control systems: expected performance benefits of integrated control	P. Haves, R.J. Hitchcock P. Xu	LBNL	2007	A small single story prototypical office building. Seven locations: Seattle, Miami, Los Angeles, Denver, Chicago, Boston, and Atlanta	Active façade with EC windows and light-redirecting windows.	EnergyPlus	Site energy for cooling, heating, fan, and lighting. HVAC and whole building source energy. A qualitative assessment that considers HVAC, lighting, active facades (variable window transmission and natural ventilation) and on-site generation. A quantitative assessment that considers HVAC, lighting and active facades.	The study tried to determine whether integrated control at the whole-building level can result in significant reductions in energy consumption in very low energy buildings. The results to date indicate significant benefits in the range 5% to 60% of HVAC source energy, depending on climate and building size
Assessment of the technical potential for achieving net	B. Griffith, N. Long, P. Torcellini,	NREL/TP-550-41957	2007	DOE commercial benchmarks which have 15 prototype	Baseline of ASHRAE 90.1-2004 windows. ASHRAE	EnergyPlus	Total site energy, net site energy, net source energy, energy cost, peak electrical	The study assessed the technical potential for zero-energy building (ZEB) technologies and practices to

zero-energy buildings in the commercial sector	R. Judkoff, D. Crawley, J. Ryan			commercial buildings in 16 locations.	189.1 windows (metal framing). Dynamic windows.		demand, and equivalent carbon from energy.	reduce the impact of commercial buildings on the U.S. energy system. The ZEB goal was found to be largely achievable. Based on the projections of future performance levels from currently known technologies and design practices, 62% of buildings could reach net zero. Calculated according to floor area, rather than by number of buildings, 47% of commercial building floor area could reach the ZEB goal.

Methodology for Modeling and Analysis

Analysis studies based on computer simulations are a reliable way to provide quick assessment of relative benefits of different windows technologies. This study looks at the energy impact of windows in terms of whole building energy performance which takes into account of integration and interaction of building components and systems. This analysis is not a market penetration study, a life cycle cost analysis, or an environmental impact study.

Office buildings are the most common commercial building type and they consume the greatest amount energy in the commercial building sector (Figure 6 to Figure 8). Office buildings normally have more windows, and energy use related to windows represents a higher portion of the building's total energy use. Daylighting is also more common in office buildings.

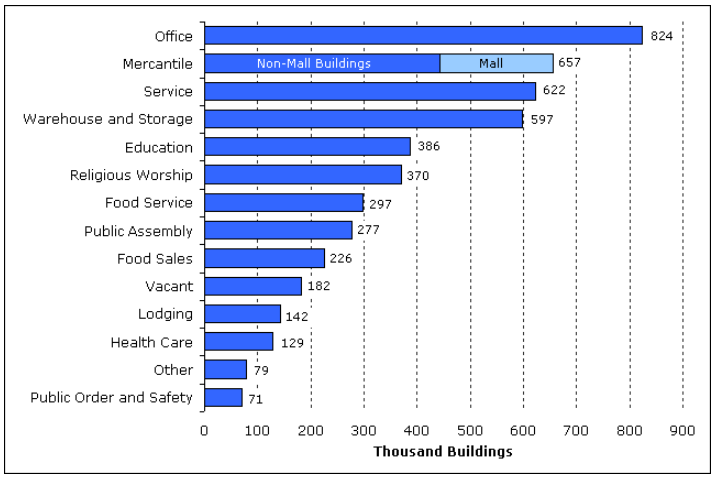


Figure 6 – Number of commercial buildings by building type (EIA 2003 CBECS)

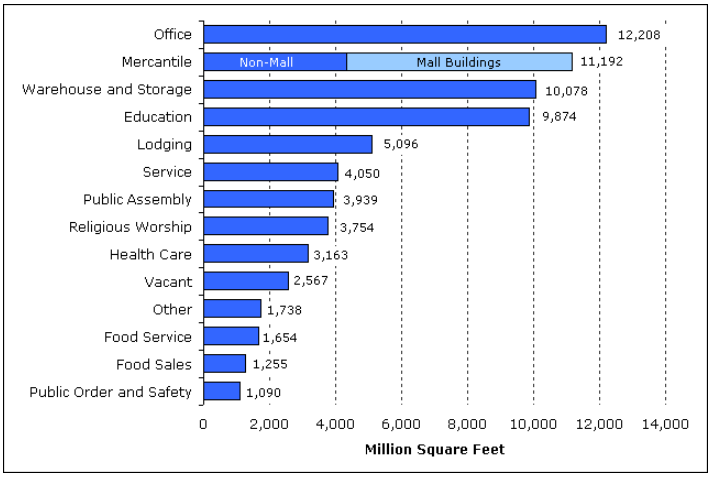


Figure 7 – Commercial building floor area by building type (EIA 2003 CBECS)

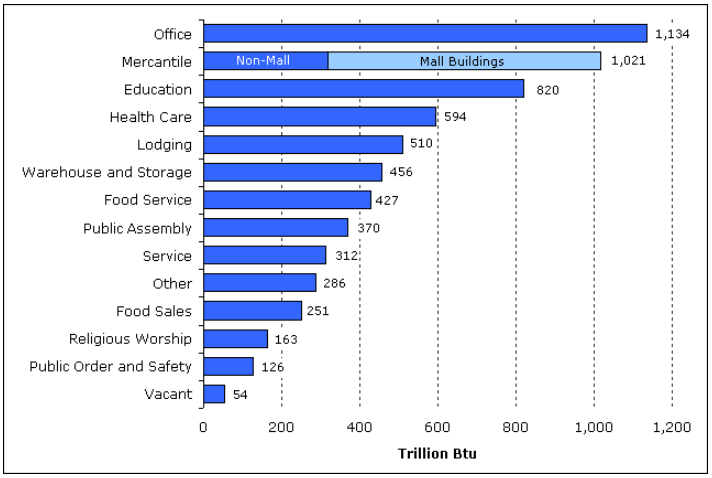


Figure 8 – Commercial building energy use by building type (EIA 2003 CBECS)

This study assesses the energy impact of window technologies for large office buildings in the US. The prototypical large office building is chosen from the US DOE commercial building benchmarks which were developed based on the US EIA 2003 commercial building energy consumption survey. The building characteristics, including envelope constructions, lighting, and HVAC are set to meet the minimum requirements of ASHRAE 90.1-2004 Energy Standard for Buildings Except Low-Rise Residential Buildings. ASHRAE 90.1-2004 is the basis of DOE's multi-stage energy savings targets toward ZEB goal.

Several window technologies were studied: the existing stock based on average commercial window sales, the baseline windows based on ASHRAE Standard 90.1-2004, the high performance windows based on ASHRAE Standard 189.1P, the emerging triple pane low-e windows, the dynamic windows, the highly insulating windows, and the hypothetical technically feasible highly insulating dynamic windows. The overall properties of windows are represented as U-factor, SHGC (Solar Heat Gain Coefficient), and VT (Visible Transmittance). Most These windows were created with Window 6 and the IGDB/CGDB database which provides full spectral data.

Different types of interior shades and controls were studied. Daylighting benefits in terms of electric lighting energy savings were estimated separately for the office building.

Window impacts are quantified as a set of performance metrics including energy use of cooling, heating, fan, and lighting, peak electric demand, calculated design cooling and heating capacities, thermal comfort, and visual comfort. These metrics are normalized by window area for each climate zone and further scaled to estimate the nationwide impacts based on regional window sales in terms of window area.

EnergyPlus version 2.2, released on April 22, 2008, is the simulation engine to calculate the energy savings of different window technologies compared with the baseline windows. EnergyPlus has advanced features and more accurate approach than DOE-2 to model windows, shading controls, daylighting, thermal and visual comfort. EnergyPlus has detailed layer-by-layer definitions of windows in

the IDF files, and use the spectral data from the IGDB database. An Excel spreadsheet was created to manage the parametric runs and process results for reporting.

The TMY3 weather data was used in the simulations. The TMY3 weather data represented typical weather conditions during 1991 to 2005. The TMY3 data is available at www.energyplus.gov.

Building Prototypes

DOE has developed a set of new commercial building benchmarks for assessing the energy impacts of different types of building technologies.

Characteristics of the Large Office Building

The prototypical large office building has 12 conditioned stories above the ground and 1 unconditioned basement story. The building has a rectangle shape (240 ft X 192 ft) with the long axis along the East-West and an aspect ratio of 1.5. The total conditioned building floor area is 460,000 square feet. Each of the conditioned floors is modeled as four perimeter zones and one core zone with the space height of 10 feet. The perimeter zone depth is 15 feet. The total area of perimeter zones is about 29% of the building floor area.

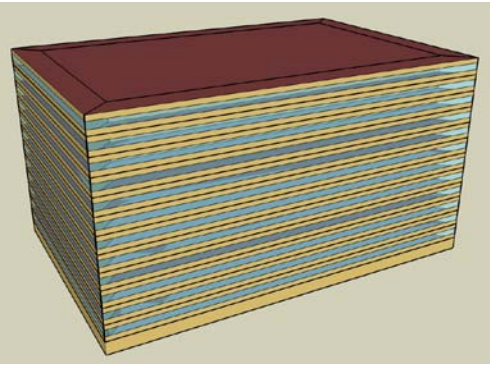


Figure 9 – The Prototypical Large Office Building

The building has a window-wall-ratio of 40% with windows evenly distributed on the four facades of the 12 above ground floors. The total window area is 38,388 square feet. The building has no skylights. Windows are modeled as continuous horizontal bands. For the 90.1-2004 baseline windows, there are interior shades with medium reflectance and medium transmittance listed in Table 3.

Table 3 – Properties of Interior Shades for the Baseline Windows

Property	Value
Solar transmittance	0.4
Solar reflectance	0.5
Visible transmittance	0.4
Visible reflectance	0.5

The interior shades are assumed to be down when the glare index exceeds 22 which is a typical setpoint for office spaces. For electrochromic (EC) windows, there are no interior shades.

The building is served by one central variable air volume system with zone reheat, one water-cooled electric chiller, and one gas-fired hot water boiler. The chiller has a COP of 4.9 and the boiler has an efficiency of 80%. The cooling and heating capacities and air flow of HVAC equipment is autosized by EnergyPlus simulations according to the peak loads calculated on the summer and winter design days.

The design lighting power density (LPD) is 1.0 W/ft^2; the design electric plug loads density (EPD) is 0.75 W/ft^2; and the design occupant density is 3.63 person/1000 ft^2 with a total of 1670 occupants in the building.

For the runs with EC windows, EC windows do not have interior shades and are automatically darkened to meet the daylight illuminance setpoint at the reference point. Each of the four perimeter zones has one daylight sensor located 2/3 back in the perimeter zone, about 10 feet from the windows (Figure 10). The view azimuth used to calculate the glare index is set to parallel to the windows. The daylight sensor has an illuminance setpoint of 500 lux. For the daylighting runs, the daylight sensor continuously dims the electrical lighting based on the amount of daylight it receives. If the available daylight is equal to or greater than 500 lux, the electrical lighting power remains at a minimum of 10%.

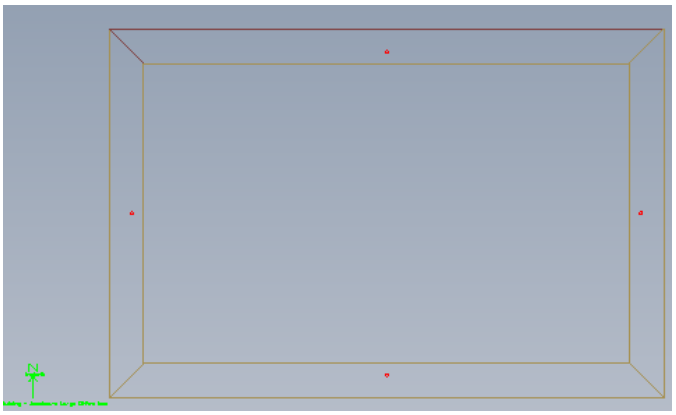


Figure 10 – Daylight Sensors in Perimeter Zones

The typical office occupancy schedules listed in **Table 73** of the appendix are used in the simulations.

Climate Zones

Five typical climates chosen from the 16 locations covered by the DOE commercial benchmarks are used in this assessment study. Table 4 lists the five locations. Figure 11 shows the climate zones on the US map.

Table 4 – The Five Typical Climates

Climate Zone	City	Climate
1A	Miami, FL	Very Hot – Humid (Tropical)
2B	Phoenix, AZ	Hot – Dry (Subtropical)
3C	San Francisco, CA	Warm – Marine (Mediterranean)
5A	Chicago, IL	Cool – Humid (warm summer, cold winter)
7	Duluth, MN	Very Cold (cool summer, very cold winter)

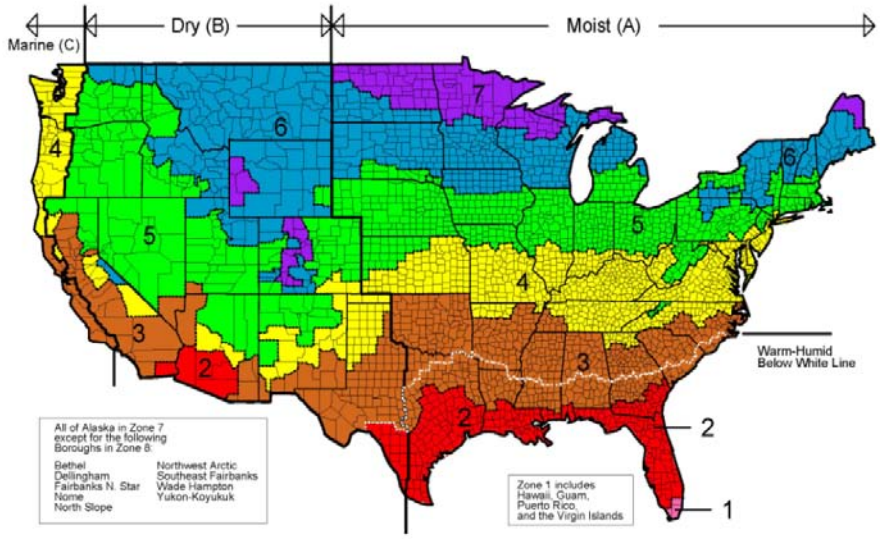


Figure 11 - Climate Zone Classifications

Window Technologies to Evaluate

Different types of window technologies are evaluated: existing stock, code baseline (ASHRAE 90.1-2004), high performance building standard (ASHRAE 189.1P), emerging window technologies, and hypothetically optimum technically feasible. The VT of the windows is not usually regulated explicitly by building energy code and standards like ASHRAE 90.1 and 189.1. In this study, the VT of a window is assumed to equal the SHGC if not specified explicitly by the sources.

Table 5 summarizes windows to be evaluated with their overall performance data U-factor, SHGC, and VT.

Table 5 – Summary of Windows to be Evaluated

Windows	Description	U-factor (Btu/h-°F-ft²)	SHGC	VT
Base Case – San Francisco	ASHRAE 90.1-2004 baseline	1.219	0.338	0.339
Base Case – Phoenix, Miami	ASHRAE 90.1-2004 baseline	1.219	0.249	0.25
Base Case – Chicago	ASHRAE 90.1-2004 baseline	0.574	0.39	0.498
Base Case – Duluth	ASHRAE 90.1-2004 baseline	0.574	0.491	0.486
AvgComSales	Existing commercial stock (average commercial sales)	0.62	0.48	0.48
Triple_Lowe	Triple pane with low-e	0.201	0.25	0.25
High_R_Tint	High insulating double pane tinted	0.291	0.28	0.28
High_R_Clear	High insulating double pane clear	0.291	0.42	0.42
189.1 – San Francisco	ASHRAE 189.1 baseline	0.549	0.25	0.25
189.1 – Phoenix	ASHRAE 189.1 baseline	0.75	0.25	0.25
189.1 – Miami	ASHRAE 189.1 baseline	1.20	0.25	0.25
189.1 – Chicago	ASHRAE 189.1 baseline	0.45	0.35	0.35
189.1 – Duluth	ASHRAE 189.1 baseline	0.35	0.45	0.45
EC_Window	Electrochromic	0.298	0.39 clear 0.086 dark	0.599 clear 0.034 dark
EC_HR_Window	Electrochromic, highly insulating	0.118	0.349 clear 0.043 dark	0.557 clear 0.031 dark

Existing Stock

The average commercial windows based on the commercial sales (DOE MYP 2008-2012) have performance listed in Table 6. These windows are double pane with low-e coating.

Table 6 – Average Commercial Window Properties Based on Sales

Windows	U-factor (Btu/h-°F-ft²)	SHGC	VT
Average commercial sales (Business as Usual)	0.62	0.48	0.48

Baseline Windows

The baseline windows are minimally compliant with ASHRAE standard 90.1-2004. Table 7 lists the overall properties of the baseline windows. For San Francisco, Phoenix, and Miami, the baseline windows are single pane with low-e. For Chicago and Duluth, the baseline windows are double pane with low-e.

Table 7 – Baseline Windows Minimally Compliant with ASHRAE 90.1-2004

Location	Climate Zone	U-factor (Btu/h-°F-ft²)	SHGC	VT
San Francisco	3C	1.219	0.338	0.339
Phoenix	2B	1.219	0.249	0.25
Miami	1A	1.219	0.249	0.25
Chicago	5A	0.574	0.39	0.498
Duluth	7	0.574	0.491	0.486

Windows for High Performance Buildings

The ASHRAE Standard 189.1P: Standard for the Design of High-Performance Green Buildings except Low-Rise Residential Buildings, defines minimum windows requirements, under the category of 'metal framing all others', as listed in Table 8.

Table 8 – Window Properties in ASHRAE 189.1P (Second Draft)

Location	Climate Zones	U-factor (Btu/h-°F-ft²)	SHGC	VT
Miami (1A)	1A, 1B	1.20	0.25	0.25
Phoenix (2B)	2A, 2B	0.75	0.25	0.25
San Francisco (3C)	3A, 3B, 3C	0.55	0.25	0.25
Chicago (5A)	5A, 5B, 5C	0.45	0.35	0.35
Duluth	7	0.35	0.45	0.45

Emerging Technologies

Emerging window technologies include triple pane Low-e windows, dynamic windows, and highly insulating windows. Table 9 to Table 11 list performance data of these windows.

Table 9 – Triple Pane Low-e Windows (from DOE MYP 2008-2012)

Windows	U-factor (Btu/h-°F-ft²)	SHGC	VT
Triple pane Low-e	0.201	0.25	0.25

Table 10 - Dynamic windows – Electrochromic, auto switchable windows

State	U-factor (Btu/h-°F-ft²)	SHGC	VT
Clear	0.298	0.39	0.599
Dark	0.298	0.086	0.034

Table 11 - Highly insulating windows – Double pane with low-e

Windows	U-factor (Btu/h-°F-ft²)	SHGC	VT
Selective tint IGU	0.291	0.28	0.28
Selective clear IGU	0.291	0.42	0.42

Hypothetically Optimum Technically Feasible

The most energy efficient windows would be the hypothetically optimum windows that are technically feasible. Table 12 shows the performance data of such windows.

Table 12 – Highly Insulating Dynamic Windows – Triple pane, low-e, EC windows

State	U-factor (Btu/h-°F-ft²)	SHGC	VT
Clear	0.118	0.349	0.557
Dark	0.118	0.043	0.031

Shading Controls

Different shading control strategies are evaluated: the interior shades always on (Shade OnAll), always off (Shade OffAll), on if high glare (Shade OnIfHG, the baseline), and meeting the daylight illuminance setpoint for EC windows.

Simulation Results and Energy Savings Analysis

Simulation results and the calculated energy savings are summarized in tables and graphs in the appendix for all window technologies and shading controls in the five climates. The site energy and source energy are calculated as follows for all five climates:

Site Energy (kBtu) = Electricity Use (kWh) *3.413 + Natural Gas Use (kBtu)

Source Energy (kBtu) = Electricity Use (kWh) *3.413*3.095 + Natural Gas Use (kBtu) *1.092

The above source energy formula assumes a source factor of 3.095 for electricity and 1.092 for natural gas. The site energy EUI listed in Table 15 to Table 20 is calculated as,

Site Energy EUI (kBtu/ft²) = Site Energy (kBtu) / Building Floor Area (ft²)

Detailed energy savings of the eight window technologies with and without daylighting controls for the three types of shading controls are calculated and listed in Table 53 to Table 72, which show,

- HVAC electricity end uses (cooling, fan, pump, and cooling tower, kWh)
- Lighting electricity use for daylighting cases only (kWh)
- HVAC space heating gas use (Therm)
- Whole building electricity and gas savings (kWh, Therm)
- Whole building electricity and gas savings in percentages (%)
- Whole building electricity and gas savings per square foot of window area (kWh/ft², kBtu/ft²)

For each combination of location, shading controls, and daylighting controls, eleven graphs are shown:

- the annual building electricity consumption per square foot of floor area (kWh/ft²)
- the annual building gas consumption per square foot of floor area (kBtu/ft²)
- the annual building site energy consumption per square foot of floor area (kBtu/ft²)
- the annual building source energy consumption per square foot of floor area (kBtu/ft²)
- the annual building peak electricity demand per square foot of floor area (W/ft²)
- the electricity end uses per square foot of floor area (kWh/ft²)
- the monthly electricity consumption per square foot of floor area (kWh/ft²)
- the monthly gas consumption per square foot of floor area (kBtu/ft²)
- the design chiller capacity (Ton)
- the design boiler capacity (MMBH, million Btu/h)
- for daylighting cases, the annual number of hours daylight glare index exceeding the max setpoint

Summary of whole building energy use, including electricity, gas, site energy, and source energy, is listed in Table 13 and Table 14, while energy savings on the basis of per square foot of window area are listed in Table 15 and Table 16. Table 15 shows the building energy savings without daylighting controls for all cases including the baseline cases, while Table 16 is for all cases with daylighting controls. The cells in both tables are filled with colors: the red color represents negative energy savings while the green for positive savings. The depth of the colors represents the relative magnitude of energy savings – the darker the color, the more energy saved (if green) or consumed (if red). For cases with no daylighting controls, the annual lighting energy use is always 1,427,703 kWh, representing from 20.4% of total electricity use in Miami to 28.5% in Duluth. The energy savings on the basis of per square foot of building floor area are listed in Table 47 to Table 52.

For the results of the no daylighting cases shown in Table 15 and Figure 12, the following can be observed:

- The existing commercial windows consume more site energy and more source energy than the baseline windows meeting the ASHRAE 90.1-2004 requirements for the five climates with or without daylighting controls, except the San Francisco with daylighting case shows a marginal 0.4% site energy savings. The existing commercial windows do save building heating gas use except for the Duluth climate, but consume more electricity for all five climates. This implies

that the existing commercial windows do not meet the energy performance of the baseline 90.1-2004 windows.

- All seven alternative windows save building heating energy. The savings are much higher in climates where heating is more demanded such as Duluth than in Phoenix. Miami only requires marginal space heating.

- The two EC windows show better energy performance than the other six. The highly insulated EC window (EC_HR_Window) demonstrates the best energy performance for Duluth, Chicago, and Phoenix; while for San Francisco, the normal EC windows are the most energy efficient.

- Triple low-e windows show better energy performance in cold climates such as Duluth and Chicago. They are marginally better than the baseline window in climates such as San Francisco and Phoenix.

- Except for Miami, the ASHRAE 189.1 windows show better energy performance than the baseline windows. The energy savings are higher in Duluth and San Francisco.

- As can be expected (due to lower U-factors), the two highly insulated windows show better energy performance in heating climates such as Duluth and Chicago.

- For hot climates such as Miami where cooling is dominant, only the two EC windows with daylighting controls consume marginally less electricity, site energy, and source energy than the baseline windows. All other cases consume more electricity, site energy, and source energy than the baseline window. It can be concluded that for the Miami climate, the baseline window provides the best energy performance than the seven alternative windows.

- For mild climate such as San Francisco, only the two EC windows show electricity savings compared with the baseline window. Except for the existing commercial stock without daylight controls, other cases demonstrate site energy savings. Except for the existing commercial stock and the High_R_Clear windows, the other five windows demonstrate source energy savings. The EC_Window shows the best energy performance for San Francisco.

- For hot and dry climate such as Phoenix, the two EC windows save both electricity and gas use and show much better overall energy performance in site energy and source energy.

- For cold climate such as Duluth and Chicago, windows with lower U-factors such as the triple low-e window and the two EC windows save more energy.

- Window technologies that save electricity also reduce electricity peak demand and thus cooling equipment (chiller) capacity. While window technologies that save heating gas also reduce heating equipment (boiler) capacity.

By comparing results between no daylighting controls cases (Table 15) and with daylighting controls cases (Table 16), the relative energy savings percentages of the seven window technologies compared with the baseline windows across all five climates are not changed noticeably by adding the daylighting controls. On the other hand, by comparing the same window technology between with and without daylighting controls cases, the energy savings of daylighting cases in terms of electricity, site energy, and source energy are significant. The gas use for the daylighting cases obviously is higher than the without daylighting controls cases due to the contribution of lighting energy to meet space heating loads.

Energy savings from other technologies like HVAC or lighting are better quantified on the basis of building floor area, while the windows energy savings are better quantified on the basis of window area or the perimeter zone floor area. The calculated energy savings per window area are only applicable to the studied cases (WWR = 40% etc), be cautious to use the savings results for other cases with different window area or different daylighting controls.

As perimeter zones of the large office building only cover 29% of the building floor area, 71% of the floor area is core zones which do not have energy savings directly related to the changes of windows on perimeter zones. Therefore, if the percentages of energy savings were calculated on the perimeter zones basis, they would be much higher as demonstrated in the Impact of Orientation section.

Table 13 – Whole Building Energy Use (Shades On If High Glare, No Daylighting)

		End Uses								Whole Building Energy Use				Electricity End Uses		
Climates	Windows	Lighting kWh	Receptacle kWh	Cooling kWh	Fan kWh	Pump kWh	Cooling Tower kWh	Space Heating Therm	Water Heating Therm	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu	% Lighting	% Receptacle	% HVAC
San Francisco	base case	1,427,703	1,680,681	627,514	989,314	271,431	141,539	12,835	3,359	5,138,180	16,194	19,143	56,003	27.8%	32.7%	39.5%
	AvgComSales	1,427,703	1,680,681	710,458	1,102,031	301,483	157,742	5,635	3,358	5,380,097	8,993	19,247	57,770	26.5%	31.2%	42.2%
	Triple_Lowe	1,427,703	1,680,681	659,306	1,024,017	279,758	146,306	1,823	3,358	5,217,767	5,181	18,313	55,640	27.4%	32.2%	40.4%
	High_R_Tint	1,427,703	1,680,681	662,103	1,029,525	281,703	147,331	2,486	3,359	5,229,045	5,844	18,417	55,831	27.3%	32.1%	40.6%
	High_R_Clear	1,427,703	1,680,681	718,636	1,108,331	302,633	158,331	2,539	3,358	5,396,314	5,898	18,993	57,603	26.5%	31.1%	42.4%
	189.1	1,427,703	1,680,681	629,531	986,500	271,639	141,683	5,131	3,358	5,137,733	8,489	18,371	55,156	27.8%	32.7%	39.5%
	EC_Window	1,427,703	1,680,681	597,025	943,100	256,906	134,086	2,683	3,359	5,039,500	6,042	17,791	53,852	28.3%	33.4%	38.3%
	EC_HR_Window	1,427,703	1,680,681	607,244	960,261	262,578	137,236	2,025	3,359	5,075,705	5,383	17,848	54,163	28.1%	33.1%	38.8%
Miami	base case	1,427,703	1,680,681	1,663,342	1,145,481	467,161	259,489	523	1,989	6,643,856	2,512	22,909	70,401	21.5%	25.3%	53.2%
	AvgComSales	1,427,703	1,680,681	1,826,983	1,283,881	509,667	283,114	217	1,988	7,012,025	2,206	24,134	74,254	20.4%	24.0%	55.7%
	Triple_Lowe	1,427,703	1,680,681	1,728,131	1,200,097	483,925	268,817	73	1,989	6,789,350	2,062	23,360	71,888	21.0%	24.8%	54.2%
	High_R_Tint	1,427,703	1,680,681	1,736,317	1,207,914	485,206	269,528	93	1,988	6,807,347	2,082	23,424	72,080	21.0%	24.7%	54.3%
	High_R_Clear	1,427,703	1,680,681	1,823,622	1,281,947	508,447	282,439	95	1,988	7,004,836	2,084	24,098	74,165	20.4%	24.0%	55.6%
	189.1	1,427,703	1,680,681	1,665,192	1,146,939	467,603	259,736	509	1,988	6,647,855	2,497	22,921	70,442	21.5%	25.3%	53.2%
	EC_Window	1,427,703	1,680,681	1,664,597	1,154,511	471,722	262,036	104	1,988	6,661,250	2,093	22,927	70,539	21.4%	25.2%	53.3%
	EC_HR_Window	1,427,703	1,680,681	1,652,617	1,151,297	471,556	261,944	73	1,989	6,645,797	2,061	22,871	70,372	21.5%	25.3%	53.2%
Phoenix	base case	1,427,703	1,680,681	1,286,656	1,417,478	426,742	230,269	8,814	2,210	6,469,528	11,024	23,166	69,491	22.1%	26.0%	52.0%
	AvgComSales	1,427,703	1,680,681	1,410,358	1,549,469	459,092	249,172	5,015	2,210	6,776,475	7,226	23,833	72,316	21.1%	24.8%	54.1%
	Triple_Lowe	1,427,703	1,680,681	1,291,736	1,426,906	425,514	230,544	2,886	2,210	6,483,081	5,096	22,619	68,986	22.0%	25.9%	52.1%
	High_R_Tint	1,427,703	1,680,681	1,304,919	1,437,269	428,383	232,097	3,330	2,210	6,511,053	5,540	22,759	69,330	21.9%	25.8%	52.3%
	High_R_Clear	1,427,703	1,680,681	1,384,783	1,522,528	451,031	244,925	3,178	2,210	6,711,647	5,388	23,428	71,431	21.3%	25.0%	53.7%
	189.1	1,427,703	1,680,681	1,288,883	1,421,286	427,747	230,961	6,215	2,210	6,477,264	8,426	22,933	69,288	22.0%	25.9%	52.0%
	EC_Window	1,427,703	1,680,681	1,230,422	1,375,781	415,686	224,469	3,874	2,210	6,354,742	6,084	22,280	67,740	22.5%	26.4%	51.1%
	EC_HR_Window	1,427,703	1,680,681	1,203,497	1,354,758	410,500	221,669	3,070	2,210	6,298,805	5,281	22,009	67,061	22.7%	26.7%	50.7%
Chicago	base case	1,427,703	1,680,681	738,592	1,262,981	360,744	136,667	39,537	3,771	5,607,367	43,308	23,454	63,916	25.5%	30.0%	44.6%
	AvgComSales	1,427,703	1,680,681	786,994	1,334,906	382,847	143,897	39,362	3,771	5,757,028	43,133	23,947	65,476	24.8%	29.2%	46.0%
	Triple_Lowe	1,427,703	1,680,681	725,717	1,195,917	352,550	133,878	24,136	3,771	5,516,442	27,907	21,604	61,274	25.9%	30.5%	43.7%
	High_R_Tint	1,427,703	1,680,681	732,642	1,220,681	356,786	135,214	28,234	3,771	5,553,708	32,005	22,141	62,115	25.7%	30.3%	44.0%
	High_R_Clear	1,427,703	1,680,681	786,378	1,290,764	379,078	143,003	26,544	3,771	5,707,603	30,315	22,497	63,555	25.0%	29.4%	45.5%
	189.1	1,427,703	1,680,681	748,633	1,261,747	364,575	137,981	34,318	3,771	5,621,317	38,089	22,980	63,493	25.4%	29.9%	44.7%
	EC_Window	1,427,703	1,680,681	681,714	1,147,603	335,456	128,492	29,697	3,771	5,401,647	33,468	21,769	60,670	26.4%	31.1%	42.5%
	EC_HR_Window	1,427,703	1,680,681	681,586	1,130,233	337,011	128,872	22,785	3,771	5,386,083	26,555	21,024	59,751	26.5%	31.2%	42.3%
Duluth	base case	1,427,703	1,680,681	523,767	1,340,217	307,889	97,392	63,889	4,572	5,377,647	68,460	25,186	64,238	26.5%	31.3%	42.2%
	AvgComSales	1,427,703	1,680,681	537,747	1,367,958	316,361	99,339	65,372	4,572	5,429,789	69,943	25,512	64,950	26.3%	31.0%	42.8%
	Triple_Lowe	1,427,703	1,680,681	484,292	1,208,703	285,942	91,636	40,592	4,572	5,178,956	45,164	22,179	59,596	27.6%	32.5%	40.0%
	High_R_Tint	1,427,703	1,680,681	484,800	1,229,500	285,436	91,819	47,022	4,572	5,199,939	51,594	22,893	60,520	27.5%	32.3%	40.2%
	High_R_Clear	1,427,703	1,680,681	543,461	1,316,361	319,508	99,708	44,123	4,572	5,387,422	48,695	23,243	62,182	26.5%	31.2%	42.3%
	189.1	1,427,703	1,680,681	547,447	1,335,986	321,900	100,381	47,957	4,572	5,414,095	52,529	23,717	62,883	26.4%	31.0%	42.6%
	EC_Window	1,427,703	1,680,681	432,175	1,137,372	253,031	84,631	50,830	4,572	5,015,589	55,402	22,645	58,990	28.5%	33.5%	38.0%
	EC_HR_Window	1,427,703	1,680,681	436,572	1,117,936	257,636	85,839	38,431	4,572	5,006,369	43,004	21,374	57,539	28.5%	33.6%	37.9%

Table 14 – Whole Building Energy Use (Shades On If High Glare, with Daylighting)

		End Uses								Whole Building Energy Use				Electricity End Uses		
Climates	Windows	Lighting kWh	Receptacle kWh	Cooling kWh	Fan kWh	Pump kWh	Cooling Tower kWh	Space Heating Therm	Water Heating Therm	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu	% Lighting	% Receptacle	% HVAC
San Francisco	base case	1,169,292	1,680,681	603,772	955,308	262,058	136,569	15,339	3,359	4,807,681	18,697	18,266	52,787	24.3%	35.0%	40.7%
	AvgComSales	1,159,844	1,680,681	682,797	1,064,803	291,231	152,375	6,895	3,358	5,031,731	10,253	18,185	54,230	23.1%	33.4%	43.5%
	Triple_Lowe	1,182,842	1,680,681	632,233	987,897	270,567	141,533	2,314	3,358	4,895,753	5,672	17,264	52,295	24.2%	34.3%	41.5%
	High_R_Tint	1,177,153	1,680,681	635,086	993,222	271,914	142,186	3,179	3,359	4,900,239	6,537	17,365	52,437	24.0%	34.3%	41.7%
	High_R_Clear	1,162,928	1,680,681	689,703	1,070,036	292,978	153,200	3,220	3,358	5,049,525	6,578	17,879	54,017	23.0%	33.3%	43.7%
	189.1	1,182,842	1,680,681	604,747	952,272	262,231	136,931	6,387	3,359	4,819,703	9,745	17,412	51,937	24.5%	34.9%	40.6%
	EC_Window	1,157,806	1,680,681	579,211	921,103	251,183	131,206	4,341	3,359	4,721,189	7,700	16,871	50,674	24.5%	35.6%	39.9%
	EC_HR_Window	1,160,225	1,680,681	590,644	939,894	256,939	134,247	3,578	3,359	4,762,628	6,936	16,936	51,028	24.4%	35.3%	40.4%
Miami	base case	1,168,956	1,680,681	1,625,428	1,113,094	460,408	255,728	629	1,989	6,304,295	2,617	21,762	66,828	18.5%	26.7%	54.8%
	AvgComSales	1,150,553	1,680,681	1,780,842	1,246,986	499,961	277,722	271	1,989	6,636,739	2,260	22,860	70,298	17.3%	25.3%	57.3%
	Triple_Lowe	1,168,992	1,680,681	1,689,453	1,171,514	477,464	265,228	100	1,988	6,453,331	2,088	22,217	68,344	18.1%	26.0%	55.8%
	High_R_Tint	1,164,144	1,680,681	1,693,817	1,172,119	477,475	265,233	125	1,989	6,453,467	2,113	22,220	68,348	18.0%	26.0%	55.9%
	High_R_Clear	1,152,878	1,680,681	1,776,306	1,243,864	498,444	276,881	123	1,988	6,629,053	2,111	22,819	70,201	17.4%	25.4%	57.3%
	189.1	1,168,992	1,680,681	1,626,744	1,114,264	460,697	255,889	612	1,989	6,307,267	2,600	21,770	66,858	18.5%	26.6%	54.8%
	EC_Window	1,149,158	1,680,681	1,622,569	1,122,608	464,056	257,778	153	1,988	6,296,850	2,141	21,689	66,698	18.2%	26.7%	55.1%
	EC_HR_Window	1,151,003	1,680,681	1,611,267	1,119,719	463,928	257,708	110	1,988	6,284,306	2,098	21,642	66,561	18.3%	26.7%	54.9%
Phoenix	base case	1,170,622	1,680,681	1,258,339	1,391,256	420,081	226,667	9,838	2,210	6,147,642	12,048	22,171	66,205	19.0%	27.3%	53.6%
	AvgComSales	1,150,428	1,680,681	1,372,264	1,510,094	449,228	243,714	5,757	2,210	6,406,408	7,967	22,645	68,490	18.0%	26.2%	55.8%
	Triple_Lowe	1,170,661	1,680,681	1,258,617	1,396,239	419,014	226,803	3,453	2,210	6,152,014	5,663	21,547	65,554	19.0%	27.3%	53.7%
	High_R_Tint	1,165,553	1,680,681	1,271,483	1,406,353	421,528	228,206	3,973	2,210	6,173,797	6,183	21,673	65,840	18.9%	27.2%	53.9%
	High_R_Clear	1,153,050	1,680,681	1,345,400	1,481,947	441,058	239,317	3,768	2,210	6,341,453	5,979	22,225	67,588	18.2%	26.5%	55.3%
	189.1	1,170,661	1,680,681	1,258,347	1,393,233	420,436	226,997	7,100	2,210	6,150,353	9,310	21,906	65,934	19.0%	27.3%	53.6%
	EC_Window	1,149,061	1,680,681	1,196,286	1,342,522	406,861	219,681	4,834	2,210	5,995,092	7,044	21,150	64,048	19.2%	28.0%	52.8%
	EC_HR_Window	1,151,183	1,680,681	1,169,061	1,321,089	401,442	216,778	3,997	2,210	5,940,233	6,207	20,879	63,378	19.4%	28.3%	52.3%
Chicago	base case	1,170,119	1,680,681	704,578	1,211,083	344,353	131,267	42,573	3,771	5,242,081	46,343	22,512	60,392	22.3%	32.1%	45.6%
	AvgComSales	1,168,461	1,680,681	751,953	1,283,892	366,392	138,672	42,107	3,771	5,390,047	45,878	22,970	61,903	21.7%	31.2%	47.1%
	Triple_Lowe	1,197,300	1,680,681	691,619	1,145,436	337,967	129,158	25,797	3,771	5,182,155	29,568	20,630	57,927	23.1%	32.4%	44.5%
	High_R_Tint	1,190,697	1,680,681	695,933	1,163,628	339,606	129,872	30,076	3,771	5,200,411	33,847	21,120	58,587	22.9%	32.3%	44.8%
	High_R_Clear	1,172,592	1,680,681	748,125	1,236,819	362,686	137,603	28,598	3,771	5,338,503	32,369	21,443	59,883	22.0%	31.5%	46.6%
	189.1	1,179,647	1,680,681	713,350	1,209,536	348,097	132,656	36,625	3,771	5,263,966	40,396	21,992	59,973	22.4%	31.9%	45.7%
	EC_Window	1,165,961	1,680,681	650,436	1,099,917	320,489	123,917	32,810	3,771	5,041,397	36,581	20,851	57,207	23.1%	33.3%	43.5%
	EC_HR_Window	1,169,267	1,680,681	648,647	1,081,061	321,039	124,011	25,469	3,771	5,024,705	29,240	20,060	56,229	23.3%	33.4%	43.3%
Duluth	base case	1,174,767	1,680,681	492,258	1,286,797	288,692	92,783	68,386	4,572	5,015,975	72,958	24,402	60,911	23.4%	33.5%	43.1%
	AvgComSales	1,172,025	1,680,681	505,339	1,312,583	296,489	94,617	69,805	4,572	5,061,731	74,377	24,700	61,549	23.2%	33.2%	43.6%
	Triple_Lowe	1,204,317	1,680,681	451,367	1,155,219	263,761	87,211	43,568	4,572	4,842,553	48,140	21,329	56,371	24.9%	34.7%	40.4%
	High_R_Tint	1,197,033	1,680,681	454,336	1,177,617	265,194	87,608	50,635	4,572	4,862,470	55,207	22,104	57,353	24.6%	34.6%	40.8%
	High_R_Clear	1,176,847	1,680,681	507,242	1,261,797	298,281	94,989	47,568	4,572	5,019,836	52,140	22,334	58,679	23.4%	33.5%	43.1%
	189.1	1,174,261	1,680,681	512,336	1,282,503	300,950	95,681	51,745	4,572	5,046,408	56,317	22,842	59,415	23.3%	33.3%	43.4%
	EC_Window	1,168,994	1,680,681	410,658	1,093,525	238,686	81,164	56,920	4,572	4,673,706	61,492	22,088	56,047	25.0%	36.0%	39.0%
	EC_HR_Window	1,172,872	1,680,681	409,661	1,071,186	239,203	81,964	43,120	4,572	4,655,564	47,692	20,646	54,348	25.2%	36.1%	38.7%

Table 15 – Whole Building Energy Use and Savings (Shades On If High Glare, No Daylighting)

Climates	Windows	Energy Savings per ft² of Window Area						Whole Building Energy Use				Site Energy EUI kBtu/ft²
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu	
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,138,180	16,194	19,143	56,003	41.6
	AvgComSales	-6.3	18.8	-2.7	-0.5%	-46.0	-3.2%	5,380,097	8,993	19,247	57,770	41.8
	Triple_Lowe	-2.1	28.7	21.6	4.3%	9.5	0.6%	5,217,767	5,181	18,313	55,640	39.8
	High_R_Tint	-2.4	27.0	18.9	3.8%	4.5	0.3%	5,229,045	5,844	18,417	55,831	40.0
	High_R_Clear	-6.7	26.8	3.9	0.8%	-41.7	-2.9%	5,396,314	5,898	18,993	57,603	41.3
	189.1	0.0	20.1	20.1	4.0%	22.1	1.5%	5,137,733	8,489	18,371	55,156	39.9
	EC_Window	2.6	26.4	35.2	7.1%	56.0	3.8%	5,039,500	6,042	17,791	53,852	38.7
	EC_HR_Window	1.6	28.2	33.7	6.8%	47.9	3.3%	5,075,705	5,383	17,848	54,163	38.8
Miami	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,643,856	2,512	22,909	70,401	49.8
	AvgComSales	-9.6	0.8	-31.9	-5.3%	-100.4	-5.5%	7,012,025	2,206	24,134	74,254	52.4
	Triple_Lowe	-3.8	1.2	-11.7	-2.0%	-38.7	-2.1%	6,789,350	2,062	23,360	71,888	50.8
	High_R_Tint	-4.3	1.1	-13.4	-2.2%	-43.7	-2.4%	6,807,347	2,082	23,424	72,080	50.9
	High_R_Clear	-9.4	1.1	-31.0	-5.2%	-98.1	-5.3%	7,004,836	2,084	24,098	74,165	52.4
	189.1	-0.1	0.0	-0.3	-0.1%	-1.1	-0.1%	6,647,855	2,497	22,921	70,442	49.8
	EC_Window	-0.5	1.1	-0.5	-0.1%	-3.6	-0.2%	6,661,250	2,093	22,927	70,539	49.8
	EC_HR_Window	-0.1	1.2	1.0	0.2%	0.8	0.0%	6,645,797	2,061	22,871	70,372	49.7
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,469,528	11,024	23,166	69,491	50.3
	AvgComSales	-8.0	9.9	-17.4	-2.9%	-73.6	-4.1%	6,776,475	7,226	23,833	72,316	51.8
	Triple_Lowe	-0.4	15.4	14.2	2.4%	13.2	0.7%	6,483,081	5,096	22,619	68,986	49.1
	High_R_Tint	-1.1	14.3	10.6	1.8%	4.2	0.2%	6,511,053	5,540	22,759	69,330	49.5
	High_R_Clear	-6.3	14.7	-6.8	-1.1%	-50.5	-2.8%	6,711,647	5,388	23,428	71,431	50.9
	189.1	-0.2	6.8	6.1	1.0%	5.3	0.3%	6,477,264	8,426	22,933	69,288	49.8
	EC_Window	3.0	12.9	23.1	3.8%	45.6	2.5%	6,354,742	6,084	22,280	67,740	48.4
	EC_HR_Window	4.4	15.0	30.1	5.0%	63.3	3.5%	6,298,805	5,281	22,009	67,061	47.8
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,607,367	43,308	23,454	63,916	51.0
	AvgComSales	-3.9	0.5	-12.8	-2.1%	-40.6	-2.4%	5,757,028	43,133	23,947	65,476	52.0
	Triple_Lowe	2.4	40.1	48.2	7.9%	68.8	4.1%	5,516,442	27,907	21,604	61,274	46.9
	High_R_Tint	1.4	29.4	34.2	5.6%	46.9	2.8%	5,553,708	32,005	22,141	62,115	48.1
	High_R_Clear	-2.6	33.8	24.9	4.1%	9.4	0.6%	5,707,603	30,315	22,497	63,555	48.9
	189.1	-0.4	13.6	12.3	2.0%	11.0	0.7%	5,621,317	38,089	22,980	63,493	49.9
	EC_Window	5.4	25.6	43.9	7.2%	84.6	5.1%	5,401,647	33,468	21,769	60,670	47.3
	EC_HR_Window	5.8	43.6	63.3	10.4%	108.5	6.5%	5,386,083	26,555	21,024	59,751	45.7
Duluth	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,377,647	68,460	25,186	64,238	54.7
	AvgComSales	-1.4	-3.9	-8.5	-1.3%	-18.5	-1.1%	5,429,789	69,943	25,512	64,950	55.4
	Triple_Lowe	5.2	60.7	78.3	11.9%	120.9	7.2%	5,178,956	45,164	22,179	59,596	48.2
	High_R_Tint	4.6	43.9	59.7	9.1%	96.9	5.8%	5,199,939	51,594	22,893	60,520	49.7
	High_R_Clear	-0.3	51.5	50.6	7.7%	53.6	3.2%	5,387,422	48,695	23,243	62,182	50.5
	189.1	-0.9	41.5	38.3	5.8%	35.3	2.1%	5,414,095	52,529	23,717	62,883	51.5
	EC_Window	9.4	34.0	66.2	10.1%	136.7	8.2%	5,015,589	55,402	22,645	58,990	49.2
	EC_HR_Window	9.7	66.3	99.3	15.1%	174.5	10.4%	5,006,369	43,004	21,374	57,539	46.4

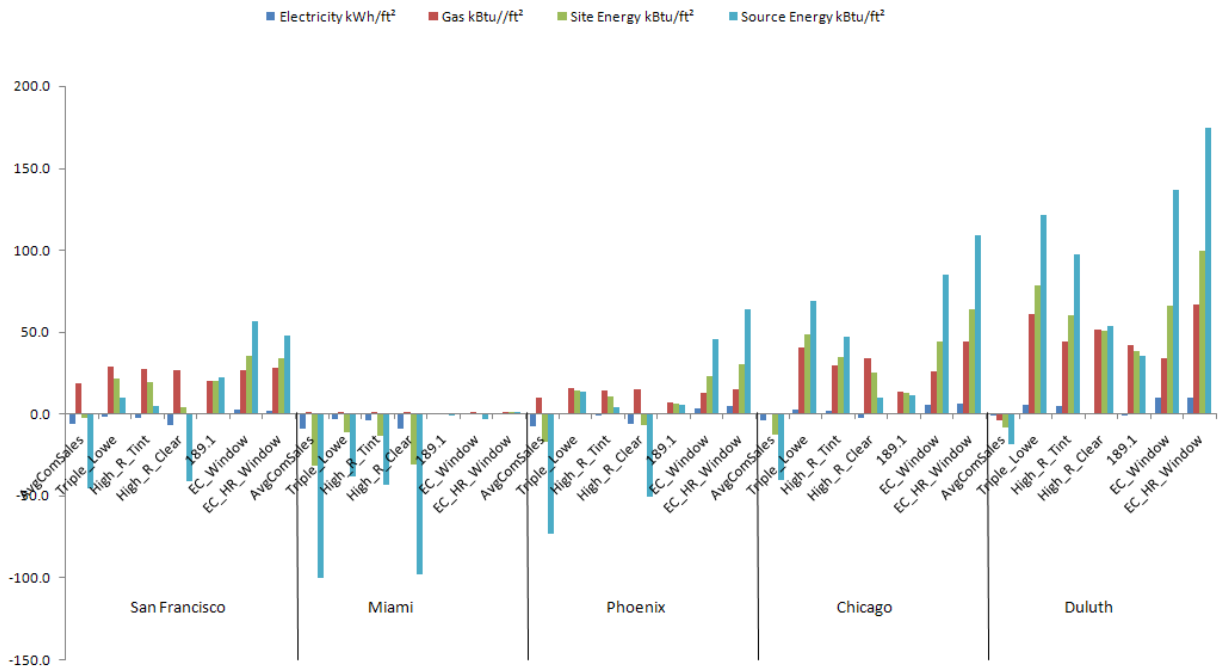


Figure 12 - Building Energy Savings per Square Foot of Window Area (Shades On If High Glare, No Daylighting)

Table 16 – Whole Building Energy Use and Savings (Shades On If High Glare, With Daylighting)

Climates	Windows	Energy Savings per ft² of Window Area						Whole Building Energy Use				Site Energy EUI kBtu/ft²
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu	
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4,807,681	18,697	18,266	52,787	39.7
	AvgComSales	-5.8	22.0	2.1	0.4%	-37.6	-2.7%	5,031,731	10,253	18,185	54,230	39.5
	Triple_Lowe	-2.3	33.9	26.1	5.5%	12.8	0.9%	4,895,753	5,672	17,264	52,295	37.5
	High_R_Tint	-2.4	31.7	23.5	4.9%	9.1	0.7%	4,900,239	6,537	17,365	52,437	37.7
	High_R_Clear	-6.3	31.6	10.1	2.1%	-32.0	-2.3%	5,049,525	6,578	17,879	54,017	38.8
	189.1	-0.3	23.3	22.2	4.7%	22.1	1.6%	4,819,703	9,745	17,412	51,937	37.8
	EC_Window	2.3	28.6	36.3	7.6%	55.0	4.0%	4,721,189	7,700	16,871	50,674	36.7
	EC_HR_Window	1.2	30.6	34.6	7.3%	45.8	3.3%	4,762,628	6,936	16,936	51,028	36.8
Miami	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,304,295	2,617	21,762	66,828	47.3
	AvgComSales	-8.7	0.9	-28.6	-5.0%	-90.4	-5.2%	6,636,739	2,260	22,860	70,298	49.7
	Triple_Lowe	-3.9	1.4	-11.9	-2.1%	-39.5	-2.3%	6,453,331	2,088	22,217	68,344	48.3
	High_R_Tint	-3.9	1.3	-11.9	-2.1%	-39.6	-2.3%	6,453,467	2,113	22,220	68,348	48.3
	High_R_Clear	-8.5	1.3	-27.5	-4.9%	-87.9	-5.0%	6,629,053	2,111	22,819	70,201	49.6
	189.1	-0.1	0.0	-0.2	0.0%	-0.8	0.0%	6,307,267	2,600	21,770	66,858	47.3
	EC_Window	0.2	1.2	1.9	0.3%	3.4	0.2%	6,296,850	2,141	21,689	66,698	47.1
	EC_HR_Window	0.5	1.4	3.1	0.6%	7.0	0.4%	6,284,306	2,098	21,642	66,561	47.0
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,147,642	12,048	22,171	66,205	48.2
	AvgComSales	-6.7	10.6	-12.3	-2.1%	-59.5	-3.5%	6,406,408	7,967	22,645	68,490	49.2
	Triple_Lowe	-0.1	16.6	16.3	2.8%	17.0	1.0%	6,152,014	5,663	21,547	65,554	46.8
	High_R_Tint	-0.7	15.3	13.0	2.2%	9.5	0.6%	6,173,797	6,183	21,673	65,840	47.1
	High_R_Clear	-5.0	15.8	-1.4	-0.2%	-36.0	-2.1%	6,341,453	5,979	22,225	67,588	48.3
	189.1	-0.1	7.1	6.9	1.2%	7.1	0.4%	6,150,353	9,310	21,906	65,934	47.6
	EC_Window	4.0	13.0	26.6	4.6%	56.2	3.3%	5,995,092	7,044	21,150	64,048	46.0
	EC_HR_Window	5.4	15.2	33.7	5.8%	73.6	4.3%	5,940,233	6,207	20,879	63,378	45.4
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,242,081	46,343	22,512	60,392	48.9
	AvgComSales	-3.9	1.2	-11.9	-2.0%	-39.4	-2.5%	5,390,047	45,878	22,970	61,903	49.9
	Triple_Lowe	1.6	43.7	49.0	8.4%	64.2	4.1%	5,182,155	29,568	20,630	57,927	44.8
	High_R_Tint	1.1	32.6	36.3	6.2%	47.0	3.0%	5,200,411	33,847	21,120	58,587	45.9
	High_R_Clear	-2.5	36.4	27.8	4.7%	13.3	0.8%	5,338,503	32,369	21,443	59,883	46.6
	189.1	-0.6	15.5	13.5	2.3%	10.9	0.7%	5,263,966	40,396	21,992	59,973	47.8
	EC_Window	5.2	25.4	43.3	7.4%	83.0	5.3%	5,041,397	36,581	20,851	57,207	45.3
	EC_HR_Window	5.7	44.6	63.9	10.9%	108.4	6.9%	5,024,705	29,240	20,060	56,229	43.6
Duluth	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,015,975	72,958	24,402	60,911	53.0
	AvgComSales	-1.2	-3.7	-7.8	-1.2%	-16.6	-1.0%	5,061,731	74,377	24,700	61,549	53.7
	Triple_Lowe	4.5	64.7	80.1	12.6%	118.3	7.5%	4,842,553	48,140	21,329	56,371	46.3
	High_R_Tint	4.0	46.2	59.9	9.4%	92.7	5.8%	4,862,470	55,207	22,104	57,353	48.0
	High_R_Clear	-0.1	54.2	53.9	8.5%	58.1	3.7%	5,019,836	52,140	22,334	58,679	48.5
	189.1	-0.8	43.3	40.6	6.4%	39.0	2.5%	5,046,408	56,317	22,842	59,415	49.6
	EC_Window	8.9	29.9	60.3	9.5%	126.7	8.0%	4,673,706	61,492	22,088	56,047	48.0
	EC_HR_Window	9.4	65.8	97.8	15.4%	171.0	10.8%	4,655,564	47,692	20,646	54,348	44.9

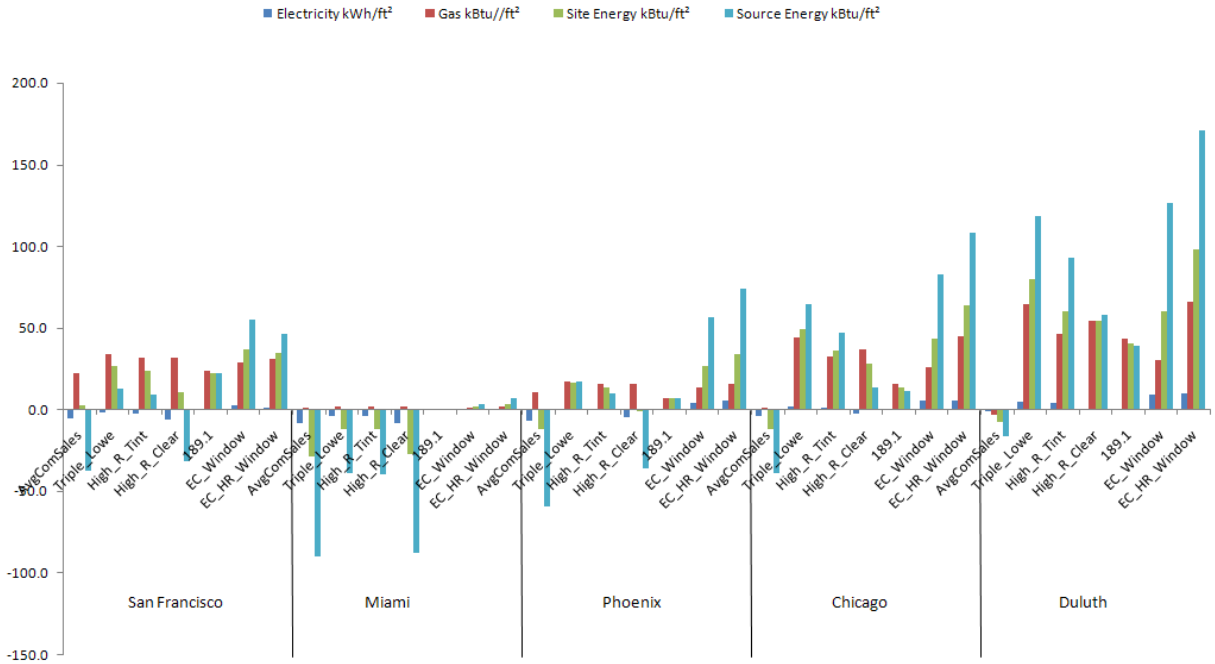


Figure 13 - Building Energy Savings per Square Foot of Window Area (Shades On If High Glare, Daylighting)

Table 17 – Whole Building Energy Use and Savings (Shades Always Off, No Daylighting)

		Energy Savings per ft² of Window Area						Whole Building Energy Use				Site
Climates	Windows	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu	Energy EUI kBtu/ft2
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,138,192	16,178	19,141	56,001	41.6
	AvgComSales	-6.3	19.2	-2.4	-0.5%	-45.7	-3.1%	5,380,736	8,817	19,232	57,757	41.8
	Triple_Lowe	-2.1	28.8	21.7	4.3%	9.5	0.6%	5,217,900	5,140	18,309	55,637	39.8
	High_R_Tint	-2.4	27.1	19.0	3.8%	4.6	0.3%	5,228,972	5,785	18,411	55,824	40.0
	High_R_Clear	-6.8	27.0	4.0	0.8%	-41.9	-2.9%	5,397,861	5,797	18,988	57,608	41.3
	189.1	0.0	20.2	20.2	4.1%	22.2	1.5%	5,137,639	8,438	18,365	55,150	39.9
	EC_Window	-4.1	25.7	11.6	2.3%	-15.4	-1.1%	5,296,202	6,316	18,694	56,592	40.6
	EC_HR_Window	-3.5	29.0	17.0	3.4%	-5.6	-0.4%	5,273,856	5,033	18,489	56,216	40.2
Miami	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,641,616	2,502	22,901	70,376	49.8
	AvgComSales	-9.8	0.8	-32.5	-5.4%	-102.2	-5.6%	7,016,374	2,194	24,148	74,298	52.5
	Triple_Lowe	-3.9	1.2	-12.2	-2.0%	-40.0	-2.2%	6,791,716	2,060	23,368	71,912	50.8
	High_R_Tint	-4.4	1.1	-13.8	-2.3%	-45.0	-2.5%	6,809,772	2,078	23,432	72,105	50.9
	High_R_Clear	-9.6	1.1	-31.7	-5.3%	-100.2	-5.5%	7,010,472	2,079	24,116	74,224	52.4
	189.1	-0.1	0.0	-0.3	0.0%	-0.9	-0.1%	6,645,172	2,488	22,911	70,412	49.8
	EC_Window	-6.3	1.1	-20.3	-3.4%	-65.0	-3.5%	6,882,388	2,089	23,681	72,873	51.5
	EC_HR_Window	-4.8	1.2	-15.1	-2.5%	-49.1	-2.7%	6,824,944	2,045	23,480	72,262	51.0
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,471,664	10,979	23,169	69,508	50.3
	AvgComSales	-8.2	10.3	-17.5	-2.9%	-74.8	-4.1%	6,784,736	7,006	23,839	72,379	51.8
	Triple_Lowe	-0.4	15.5	14.1	2.3%	12.6	0.7%	6,487,328	5,022	22,626	69,023	49.2
	High_R_Tint	-1.1	14.4	10.6	1.8%	3.9	0.2%	6,514,728	5,448	22,763	69,359	49.5
	High_R_Clear	-6.4	14.9	-7.0	-1.2%	-51.7	-2.9%	6,719,194	5,242	23,439	71,494	50.9
	189.1	-0.2	6.9	6.1	1.0%	5.1	0.3%	6,480,414	8,343	22,935	69,313	49.8
	EC_Window	-2.9	14.2	4.3	0.7%	-15.3	-0.8%	6,583,878	5,511	23,005	70,096	50.0
	EC_HR_Window	0.0	16.9	17.1	2.8%	18.9	1.0%	6,470,006	4,478	22,513	68,781	48.9
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,606,753	43,110	23,432	63,888	50.9
	AvgComSales	-3.9	0.9	-12.5	-2.1%	-40.6	-2.4%	5,758,328	42,752	23,913	65,448	52.0
	Triple_Lowe	2.3	40.2	48.1	7.9%	68.5	4.1%	5,517,116	27,694	21,585	61,258	46.9
	High_R_Tint	1.3	29.5	34.1	5.6%	46.4	2.8%	5,555,036	31,784	22,123	62,105	48.1
	High_R_Clear	-2.7	34.5	25.3	4.2%	9.4	0.6%	5,709,658	29,873	22,459	63,528	48.8
	189.1	-0.4	13.8	12.4	2.0%	10.9	0.7%	5,621,764	37,831	22,955	63,470	49.9
	EC_Window	0.9	32.4	35.3	5.8%	44.5	2.7%	5,573,586	30,676	22,076	62,180	48.0
	EC_HR_Window	1.8	50.7	56.8	9.3%	74.2	4.5%	5,538,574	23,636	21,252	61,041	46.2
Duluth	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,379,661	67,977	25,144	64,206	54.6
	AvgComSales	-1.3	-3.8	-8.4	-1.3%	-18.3	-1.1%	5,431,130	69,442	25,466	64,909	55.3
	Triple_Lowe	5.2	60.3	78.0	11.9%	120.8	7.2%	5,179,850	44,832	22,149	59,570	48.1
	High_R_Tint	4.7	43.6	59.5	9.1%	96.9	5.8%	5,200,375	51,239	22,859	60,486	49.7
	High_R_Clear	-0.3	52.1	51.1	7.8%	53.8	3.2%	5,390,650	47,988	23,183	62,139	50.4
	189.1	-1.0	42.1	38.8	5.9%	35.6	2.1%	5,417,442	51,801	23,656	62,838	51.4
	EC_Window	3.5	47.0	58.8	9.0%	87.8	5.3%	5,247,111	49,916	22,886	60,835	49.7
	EC_HR_Window	5.2	78.9	96.7	14.8%	141.3	8.5%	5,179,064	37,674	21,430	58,780	46.6

Table 18 – Whole Building Energy Use and Savings (Shades Always Off, With Daylighting)

Climates	Windows	Energy Savings per ft² of Window Area						Whole Building Energy Use				Site Energy EUI
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu	kBtu/ft2
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4,806,252	18,693	18,260	52,772	39.7
	AvgComSales	-5.9	22.5	2.5	0.5%	-37.2	-2.7%	5,031,047	10,051	18,163	54,201	39.5
	Triple_Lowe	-2.3	34.0	26.2	5.5%	12.9	0.9%	4,894,425	5,629	17,255	52,276	37.5
	High_R_Tint	-2.4	31.8	23.6	5.0%	9.3	0.7%	4,899,008	6,471	17,355	52,416	37.7
	High_R_Clear	-6.3	31.9	10.3	2.2%	-31.9	-2.3%	5,048,770	6,452	17,863	53,995	38.8
	189.1	-0.3	23.4	22.4	4.7%	22.4	1.6%	4,818,044	9,700	17,401	51,914	37.8
	EC_Window	2.2	28.6	36.2	7.6%	54.7	4.0%	4,721,188	7,700	16,871	50,674	36.7
	EC_HR_Window	1.1	30.6	34.5	7.3%	45.4	3.3%	4,762,628	6,936	16,936	51,028	36.8
Miami	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,298,733	2,600	21,741	66,768	47.2
	AvgComSales	-8.8	0.9	-29.2	-5.2%	-92.2	-5.3%	6,637,797	2,242	22,862	70,308	49.7
	Triple_Lowe	-4.0	1.3	-12.3	-2.2%	-40.6	-2.3%	6,451,902	2,084	22,212	68,328	48.3
	High_R_Tint	-4.0	1.3	-12.3	-2.2%	-40.7	-2.3%	6,451,978	2,107	22,214	68,332	48.3
	High_R_Clear	-8.7	1.3	-28.3	-5.0%	-90.2	-5.2%	6,632,056	2,104	22,828	70,232	49.6
	189.1	-0.1	0.0	-0.2	0.0%	-0.8	0.0%	6,301,689	2,583	21,749	66,797	47.3
	EC_Window	0.0	1.2	1.4	0.2%	1.8	0.1%	6,296,850	2,141	21,689	66,698	47.1
	EC_HR_Window	0.4	1.3	2.6	0.5%	5.4	0.3%	6,284,306	2,098	21,642	66,561	47.0
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,145,711	11,959	22,155	66,175	48.1
	AvgComSales	-6.8	11.2	-12.2	-2.1%	-60.1	-3.5%	6,408,586	7,672	22,623	68,481	49.2
	Triple_Lowe	-0.1	16.7	16.3	2.8%	16.9	1.0%	6,150,588	5,543	21,530	65,526	46.8
	High_R_Tint	-0.7	15.4	13.0	2.3%	9.3	0.5%	6,173,083	6,039	21,656	65,817	47.1
	High_R_Clear	-5.2	16.1	-1.5	-0.3%	-36.9	-2.1%	6,343,933	5,770	22,212	67,591	48.3
	189.1	-0.1	7.2	7.0	1.2%	7.1	0.4%	6,148,730	9,181	21,888	65,903	47.6
	EC_Window	3.9	12.8	26.2	4.5%	55.4	3.2%	5,995,092	7,044	21,150	64,048	46.0
	EC_HR_Window	5.4	15.0	33.2	5.8%	72.9	4.2%	5,940,233	6,207	20,879	63,378	45.4
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,238,606	46,219	22,488	60,341	48.9
	AvgComSales	-3.9	1.8	-11.5	-2.0%	-39.1	-2.5%	5,387,725	45,542	22,928	61,841	49.8
	Triple_Lowe	1.5	43.9	49.1	8.4%	64.0	4.1%	5,180,025	29,369	20,603	57,883	44.8
	High_R_Tint	1.1	32.8	36.5	6.2%	47.3	3.0%	5,197,088	33,620	21,086	58,527	45.8
	High_R_Clear	-2.5	37.3	28.6	4.9%	13.8	0.9%	5,336,361	31,913	21,390	59,811	46.5
	189.1	-0.6	15.9	13.9	2.4%	11.4	0.7%	5,260,208	40,132	21,953	59,905	47.7
	EC_Window	5.1	25.1	42.6	7.3%	81.6	5.2%	5,041,397	36,581	20,851	57,207	45.3
	EC_HR_Window	5.6	44.2	63.2	10.8%	107.1	6.8%	5,024,706	29,240	20,060	56,229	43.6
Duluth	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,014,000	72,516	24,351	60,842	52.9
	AvgComSales	-1.2	-3.6	-7.7	-1.2%	-16.6	-1.1%	5,060,078	73,910	24,648	61,481	53.6
	Triple_Lowe	4.5	64.2	79.7	12.6%	118.0	7.4%	4,839,722	47,863	21,292	56,311	46.3
	High_R_Tint	4.0	45.8	59.6	9.4%	92.6	5.8%	4,858,994	54,934	22,064	57,286	47.9
	High_R_Clear	-0.1	54.8	54.5	8.6%	58.9	3.7%	5,017,297	51,491	22,260	58,581	48.4
	189.1	-0.8	44.0	41.3	6.5%	39.7	2.5%	5,044,380	55,616	22,765	59,317	49.5
	EC_Window	8.9	28.7	59.0	9.3%	124.9	7.9%	4,673,706	61,492	22,088	56,047	48.0
	EC_HR_Window	9.3	64.7	96.5	15.2%	169.2	10.7%	4,655,564	47,692	20,646	54,348	44.9

Table 19 – Whole Building Energy Use and Savings (Shades Always On, No Daylighting)

		Energy Savings per ft² of Window Area						Whole Building Energy Use				Site
Climates	Windows	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu	Energy EUI kBtu/ft2
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,083,739	8,246	18,162	54,560	39.5
	AvgComSales	-3.0	4.6	-5.7	-1.2%	-26.8	-1.9%	5,199,586	6,484	18,381	55,590	39.9
	Triple_Lowe	-1.0	8.5	5.1	1.1%	-1.2	-0.1%	5,121,736	4,983	17,965	54,605	39.0
	High_R_Tint	-1.6	7.4	2.0	0.4%	-8.5	-0.6%	5,143,948	5,412	18,084	54,886	39.3
	High_R_Clear	-3.6	7.6	-4.8	-1.0%	-30.1	-2.1%	5,223,536	5,330	18,347	55,717	39.9
	189.1	0.5	4.8	6.4	1.3%	10.1	0.7%	5,065,944	6,403	17,917	54,171	38.9
	EC_Window	1.8	2.0	8.3	1.8%	21.6	1.5%	5,013,130	7,469	17,844	53,730	38.8
	EC_HR_Window	0.9	3.1	6.1	1.3%	12.8	0.9%	5,049,514	7,051	17,926	54,068	38.9
Miami	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,643,044	2,193	22,875	70,358	49.7
	AvgComSales	-3.3	0.3	-10.8	-1.8%	-34.1	-1.9%	6,767,992	2,096	23,291	71,666	50.6
	Triple_Lowe	-2.5	0.3	-8.0	-1.4%	-25.6	-1.4%	6,737,422	2,065	23,184	71,340	50.4
	High_R_Tint	-2.4	0.3	-7.8	-1.3%	-24.8	-1.4%	6,734,489	2,076	23,175	71,310	50.4
	High_R_Clear	-4.0	0.3	-13.4	-2.2%	-42.1	-2.3%	6,797,392	2,062	23,388	71,973	50.8
	189.1	0.0	0.0	-0.1	0.0%	-0.4	0.0%	6,644,508	2,190	22,879	70,373	49.7
	EC_Window	0.9	0.2	3.2	0.5%	9.6	0.5%	6,608,714	2,132	22,751	69,989	49.4
	EC_HR_Window	1.4	0.2	4.9	0.8%	14.8	0.8%	6,590,074	2,099	22,685	69,788	49.3
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,380,644	7,793	22,540	68,200	49.0
	AvgComSales	-2.8	5.0	-4.4	-0.8%	-23.7	-1.3%	6,486,397	5,888	22,710	69,108	49.3
	Triple_Lowe	-0.8	6.9	4.2	0.7%	-0.9	0.0%	6,411,358	5,143	22,379	68,234	48.6
	High_R_Tint	-1.0	6.1	2.6	0.4%	-4.3	-0.2%	6,420,620	5,452	22,442	68,366	48.8
	High_R_Clear	-2.7	7.1	-2.0	-0.3%	-20.4	-1.2%	6,483,172	5,080	22,618	68,985	49.1
	189.1	-0.3	2.3	1.3	0.2%	-0.5	0.0%	6,391,642	6,922	22,490	68,220	48.9
	EC_Window	2.1	2.6	9.6	1.6%	24.6	1.4%	6,301,436	6,803	22,171	67,255	48.2
	EC_HR_Window	3.7	4.3	17.0	2.9%	43.9	2.5%	6,238,128	6,141	21,889	66,515	47.6
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,459,600	34,812	22,101	61,428	48.0
	AvgComSales	-1.2	1.3	-2.9	-0.5%	-11.5	-0.7%	5,506,494	34,319	22,211	61,869	48.3
	Triple_Lowe	0.0	20.3	20.3	3.5%	22.1	1.4%	5,459,880	27,018	21,322	60,580	46.3
	High_R_Tint	0.1	14.1	14.4	2.5%	16.0	1.0%	5,457,386	29,387	21,550	60,812	46.8
	High_R_Clear	-1.4	17.6	12.7	2.2%	3.9	0.2%	5,515,236	28,062	21,615	61,278	47.0
	189.1	-0.2	6.3	5.8	1.0%	5.3	0.3%	5,465,447	32,382	21,877	61,225	47.5
	EC_Window	2.4	-4.1	4.3	0.7%	21.3	1.3%	5,365,872	36,372	21,937	60,609	47.7
	EC_HR_Window	3.1	13.4	24.0	4.2%	47.3	3.0%	5,340,806	29,667	21,181	59,613	46.0
Duluth	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,140,158	55,431	23,073	60,308	50.1
	AvgComSales	-0.6	-2.0	-3.9	-0.7%	-8.3	-0.5%	5,162,394	56,185	23,224	60,625	50.5
	Triple_Lowe	1.5	31.2	36.2	6.0%	49.7	3.2%	5,083,372	43,467	21,683	58,402	47.1
	High_R_Tint	1.4	20.4	25.4	4.2%	37.6	2.4%	5,084,722	47,585	22,099	58,866	48.0
	High_R_Clear	-0.8	25.9	23.3	3.9%	20.0	1.3%	5,170,366	45,474	22,180	59,540	48.2
	189.1	-0.9	20.0	16.9	2.8%	12.2	0.8%	5,175,516	47,736	22,424	59,841	48.7
	EC_Window	4.0	-12.1	1.4	0.2%	28.7	1.8%	4,987,916	60,070	23,018	59,208	50.0
	EC_HR_Window	4.5	20.1	35.6	5.9%	69.8	4.4%	4,966,374	47,700	21,707	57,630	47.2

Table 20 – Whole Building Energy Use and Savings (Shades Always On, With Daylighting)

Climates	Windows	Energy Savings per ft² of Window Area						Whole Building Energy Use				Site Energy EUI
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu	kBtu/ft2
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4,793,808	9,353	17,284	51,621	37.6
	AvgComSales	-2.5	5.4	-3.1	-0.7%	-20.3	-1.5%	4,889,044	7,284	17,402	52,400	37.8
	Triple_Lowe	-2.2	10.0	2.4	0.5%	-12.5	-0.9%	4,878,680	5,526	17,191	52,099	37.4
	High_R_Tint	-1.6	9.0	3.4	0.8%	-7.5	-0.6%	4,856,694	5,897	17,153	51,907	37.3
	High_R_Clear	-3.2	9.2	-1.8	-0.4%	-24.1	-1.8%	4,918,114	5,822	17,355	52,547	37.7
	189.1	-0.5	5.2	3.3	0.7%	-0.1	0.0%	4,814,824	7,352	17,156	51,624	37.3
	EC_Window	1.9	4.3	10.8	2.4%	24.7	1.8%	4,721,188	7,700	16,871	50,674	36.7
	EC_HR_Window	0.8	6.3	9.1	2.0%	15.4	1.1%	4,762,628	6,936	16,936	51,028	36.8
Miami	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,358,261	2,235	21,908	67,356	47.6
	AvgComSales	-2.1	0.3	-7.0	-1.2%	-22.4	-1.3%	6,440,644	2,126	22,178	68,214	48.2
	Triple_Lowe	-2.3	0.4	-7.5	-1.3%	-23.9	-1.4%	6,446,602	2,082	22,194	68,272	48.2
	High_R_Tint	-2.0	0.4	-6.6	-1.2%	-21.2	-1.2%	6,436,594	2,096	22,161	68,168	48.2
	High_R_Clear	-3.0	0.4	-9.9	-1.7%	-31.5	-1.8%	6,474,288	2,082	22,288	68,564	48.4
	189.1	0.0	0.0	-0.1	0.0%	-0.5	0.0%	6,360,000	2,232	21,913	67,374	47.6
	EC_Window	1.6	0.2	5.7	1.0%	17.1	1.0%	6,296,850	2,141	21,689	66,698	47.1
	EC_HR_Window	1.9	0.4	6.9	1.2%	20.7	1.2%	6,284,306	2,098	21,642	66,561	47.0
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,105,625	8,475	21,670	65,371	47.1
	AvgComSales	-1.7	5.2	-0.6	-0.1%	-12.4	-0.7%	6,171,566	6,469	21,694	65,848	47.1
	Triple_Lowe	-0.7	7.6	5.2	0.9%	0.9	0.1%	6,132,306	5,568	21,470	65,335	46.7
	High_R_Tint	-0.8	6.6	3.9	0.7%	-1.2	-0.1%	6,136,222	5,925	21,519	65,416	46.8
	High_R_Clear	-1.7	7.6	1.9	0.3%	-9.4	-0.5%	6,169,880	5,553	21,597	65,730	46.9
	189.1	-0.3	2.5	1.6	0.3%	-0.1	0.0%	6,115,816	7,529	21,610	65,375	47.0
	EC_Window	2.9	3.7	13.5	2.4%	34.5	2.0%	5,995,092	7,044	21,150	64,048	46.0
	EC_HR_Window	4.3	5.9	20.6	3.7%	51.9	3.0%	5,940,233	6,207	20,879	63,378	45.4
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,156,880	36,774	21,264	58,447	46.2
	AvgComSales	-1.0	1.2	-2.1	-0.4%	-8.8	-0.6%	5,193,420	36,320	21,344	58,783	46.4
	Triple_Lowe	-1.1	21.4	17.7	3.2%	11.9	0.8%	5,198,911	28,541	20,584	57,992	44.7
	High_R_Tint	-0.8	14.8	11.9	2.1%	7.3	0.5%	5,189,030	31,102	20,807	58,167	45.2
	High_R_Clear	-1.1	18.7	14.7	2.7%	8.3	0.5%	5,200,952	29,611	20,698	58,130	45.0
	189.1	-0.6	6.4	4.5	0.8%	1.1	0.1%	5,178,094	34,314	21,091	58,403	45.8
	EC_Window	3.0	0.5	10.8	1.9%	32.3	2.1%	5,041,397	36,581	20,851	57,207	45.3
	EC_HR_Window	3.4	19.6	31.4	5.7%	57.8	3.8%	5,024,706	29,240	20,060	56,229	43.6
Duluth	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4,841,700	59,085	22,421	57,557	48.7
	AvgComSales	-0.2	-2.1	-2.7	-0.5%	-4.1	-0.3%	4,848,286	59,904	22,525	57,716	48.9
	Triple_Lowe	0.4	33.9	35.1	6.0%	40.8	2.7%	4,827,900	46,089	21,074	55,992	45.8
	High_R_Tint	0.7	22.2	24.5	4.2%	31.3	2.1%	4,815,861	50,578	21,482	56,355	46.7
	High_R_Clear	-0.2	28.0	27.4	4.7%	28.8	1.9%	4,848,106	48,352	21,369	56,452	46.4
	189.1	-0.4	21.3	19.8	3.4%	18.8	1.3%	4,857,958	50,912	21,659	56,836	47.1
	EC_Window	4.4	-6.3	8.7	1.5%	39.3	2.6%	4,673,706	61,492	22,088	56,047	48.0
	EC_HR_Window	4.8	29.7	46.2	7.9%	83.6	5.6%	4,655,564	47,692	20,646	54,348	44.9

Daylighting Energy Savings

Daylighting energy savings are calculated by comparing the energy performance between the cases with daylighting controls and the cases without daylighting for all eight window technologies. The daylighting energy (electricity, site and source energy) savings are significant across all five climates (Table 21) for the Shades On If High Glare scenarios, with higher savings in climates requiring none or less heating such as Miami and Phoenix. Climates with heating demand have the negative side of daylighting which reduces electrical lighting and thus its contribution to space heating. The electricity savings ranging from 8.2 to 9.8 kWh/ft² of window area are much higher to offset the heating gas penalty of up to 16 kBtu/ft² of window area. The site energy savings range from 14.5 kBtu/ft² for the EC_Window in Duluth to 33.3 kBtu/ft² for the High_R_Clear window in Miami. The source energy savings range from 76.7 kBtu/ft² for the EC_Window in Duluth to 103.3 kBtu/ft² for the High_R_Clear window in Miami.

In terms of energy savings percentage, electricity savings are around 5% for Miami and Phoenix, 6% for San Francisco and Chicago, and 7% for Duluth. Gas use increases up to 28.8% for San Francisco, up to 17.5% for Phoenix, and up to around 10% for Chicago and Duluth. Overall site energy savings range from 3% for Duluth to up to 5.9% for San Francisco.

Table 21 – Daylighting Energy Savings, Shades On If High Glare

		Energy Savings per ft² of Window Area				Energy Savings %			
Climates	Windows	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²	Electricity	Gas	Site Energy	Source Energy
San Francisco	base case	8.61	-6.52	22.8	83.8	6.4%	-15.5%	4.6%	5.7%
	AvgComSales	9.07	-3.28	27.7	92.2	6.5%	-14.0%	5.5%	6.1%
	Triple_Lowe	8.39	-1.28	27.3	87.1	6.2%	-9.5%	5.7%	6.0%
	High_R_Tint	8.57	-1.81	27.4	88.4	6.3%	-11.9%	5.7%	6.1%
	High_R_Clear	9.03	-1.77	29.0	93.4	6.4%	-11.5%	5.9%	6.2%
	189.1	8.28	-3.27	25.0	83.9	6.2%	-14.8%	5.2%	5.8%
	EC_Window	8.29	-4.32	24.0	82.8	6.3%	-27.4%	5.2%	5.9%
	EC_HR_Window	8.16	-4.05	23.8	81.7	6.2%	-28.8%	5.1%	5.8%
Miami	base case	8.85	-0.28	29.9	93.1	5.1%	-4.2%	5.0%	5.1%
	AvgComSales	9.78	-0.14	33.2	103.1	5.4%	-2.4%	5.3%	5.3%
	Triple_Lowe	8.75	-0.07	29.8	92.3	4.9%	-1.3%	4.9%	4.9%
	High_R_Tint	9.22	-0.08	31.4	97.2	5.2%	-1.5%	5.1%	5.2%
	High_R_Clear	9.79	-0.07	33.3	103.3	5.4%	-1.3%	5.3%	5.3%
	189.1	8.87	-0.27	30.0	93.4	5.1%	-4.1%	5.0%	5.1%
	EC_Window	9.49	-0.13	32.2	100.1	5.5%	-2.3%	5.4%	5.4%
	EC_HR_Window	9.42	-0.10	32.0	99.3	5.4%	-1.8%	5.4%	5.4%
Phoenix	base case	8.39	-2.67	25.9	85.6	5.0%	-9.3%	4.3%	4.7%
	AvgComSales	9.64	-1.93	30.9	99.7	5.5%	-10.3%	5.0%	5.3%
	Triple_Lowe	8.62	-1.48	27.9	89.4	5.1%	-11.1%	4.7%	5.0%
	High_R_Tint	8.79	-1.67	28.3	90.9	5.2%	-11.6%	4.8%	5.0%
	High_R_Clear	9.64	-1.54	31.3	100.1	5.5%	-11.0%	5.1%	5.4%
	189.1	8.52	-2.30	26.8	87.4	5.0%	-10.5%	4.5%	4.8%
	EC_Window	9.37	-2.50	29.4	96.2	5.7%	-15.8%	5.1%	5.5%
	EC_HR_Window	9.34	-2.41	29.4	95.9	5.7%	-17.5%	5.1%	5.5%
Chicago	base case	9.52	-7.91	24.5	91.8	6.5%	-7.0%	4.0%	5.5%
	AvgComSales	9.56	-7.15	25.5	93.1	6.4%	-6.4%	4.1%	5.5%
	Triple_Lowe	8.71	-4.33	25.4	87.2	6.1%	-6.0%	4.5%	5.5%
	High_R_Tint	9.20	-4.80	26.6	91.9	6.4%	-5.8%	4.6%	5.7%
	High_R_Clear	9.61	-5.35	27.5	95.7	6.5%	-6.8%	4.7%	5.8%
	189.1	9.31	-6.01	25.7	91.7	6.4%	-6.1%	4.3%	5.5%
	EC_Window	9.38	-8.11	23.9	90.2	6.7%	-9.3%	4.2%	5.7%
	EC_HR_Window	9.41	-6.99	25.1	91.7	6.7%	-10.1%	4.6%	5.9%
Duluth	base case	9.42	-11.72	20.4	86.7	6.7%	-6.6%	3.1%	5.2%
	AvgComSales	9.59	-11.55	21.2	88.6	6.8%	-6.3%	3.2%	5.2%
	Triple_Lowe	8.76	-7.75	22.1	84.0	6.5%	-6.6%	3.8%	5.4%
	High_R_Tint	8.79	-9.41	20.6	82.5	6.5%	-7.0%	3.4%	5.2%
	High_R_Clear	9.58	-8.97	23.7	91.3	6.8%	-7.1%	3.9%	5.6%
	189.1	9.58	-9.87	22.8	90.3	6.8%	-7.2%	3.7%	5.5%
	EC_Window	8.91	-15.87	14.5	76.7	6.8%	-11.0%	2.5%	5.0%
	EC_HR_Window	9.14	-12.21	19.0	83.1	7.0%	-10.9%	3.4%	5.5%

Several important factors should be considered in calculating the daylighting energy savings:

- The large office building used for this analysis has only 29% of floor area on the perimeter zones with daylighting, while the majority 71% of the floor area is on the core zones without daylighting. Therefore, the calculated daylighting energy savings if prorated to the whole building floor area will be significantly lower than buildings with much higher portion of perimeter zones.

- The calculated daylighting energy savings shown in Table 21 assumed windows were shaded when the perimeter zone glare index exceeded 22. Removing this constraint will probably increase the daylighting energy savings, but the savings would not be realistic in practice due to visual discomfort issues.

- Table 22 and Table 23 show daylighting energy savings for the other two shading controls scenarios.

Table 22 – Daylighting Energy Savings, Shades Always On

		Energy Savings per ft² of Window Area			
Climates	Windows	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	base case	7.55	-2.89	22.9	76.6
	AvgComSales	8.09	-2.08	25.5	83.1
	Triple_Lowe	6.33	-1.41	20.2	65.3
	High_R_Tint	7.48	-1.26	24.3	77.6
	High_R_Clear	7.96	-1.28	25.8	82.6
	189.1	6.54	-2.47	19.8	66.3
	EC_Window	7.61	-0.60	25.3	79.6
	EC_HR_Window	7.47	0.30	25.8	79.2
Miami	base case	7.42	-0.11	25.2	78.2
	AvgComSales	8.53	-0.08	29.0	89.9
	Triple_Lowe	7.58	-0.04	25.8	79.9
	High_R_Tint	7.76	-0.05	26.4	81.8
	High_R_Clear	8.42	-0.05	28.7	88.8
	189.1	7.41	-0.11	25.2	78.1
	EC_Window	8.12	-0.02	27.7	85.7
	EC_HR_Window	7.97	0.00	27.2	84.1
Phoenix	base case	7.16	-1.78	22.7	73.7
	AvgComSales	8.20	-1.51	26.5	84.9
	Triple_Lowe	7.27	-1.11	23.7	75.5
	High_R_Tint	7.41	-1.23	24.0	76.8
	High_R_Clear	8.16	-1.23	26.6	84.8
	189.1	7.19	-1.58	22.9	74.1
	EC_Window	7.98	-0.63	26.6	83.5
	EC_HR_Window	7.76	-0.17	26.3	81.7
Chicago	base case	7.89	-5.11	21.8	77.7
	AvgComSales	8.16	-5.21	22.6	80.4
	Triple_Lowe	6.80	-3.97	19.2	67.4
	High_R_Tint	6.99	-4.47	19.4	68.9
	High_R_Clear	8.19	-4.03	23.9	82.0
	189.1	7.49	-5.03	20.5	73.5
	EC_Window	8.45	-0.54	28.3	88.6
	EC_HR_Window	8.23	1.11	29.2	88.2
Duluth	base case	7.77	-9.52	17.0	71.7
	AvgComSales	8.18	-9.69	18.2	75.8
	Triple_Lowe	6.65	-6.83	15.9	62.8
	High_R_Tint	7.00	-7.80	16.1	65.4
	High_R_Clear	8.39	-7.50	21.1	80.4
	189.1	8.27	-8.27	19.9	78.3
	EC_Window	8.19	-3.71	24.2	82.3
	EC_HR_Window	8.10	0.02	27.6	85.5

Table 23 – Daylighting Energy Savings, Shades Always Off

Climates	Windows	Energy Savings per ft² of Window Area			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	base case	8.65	-6.55	22.9	84.1
	AvgComSales	9.11	-3.21	27.8	92.6
	Triple_Lowe	8.43	-1.27	27.5	87.6
	High_R_Tint	8.60	-1.79	27.5	88.8
	High_R_Clear	9.09	-1.71	29.3	94.1
	189.1	8.33	-3.29	25.1	84.3
	EC_Window	14.98	-3.61	47.5	154.2
	EC_HR_Window	13.32	-4.96	40.5	135.1
Miami	base case	8.93	-0.25	30.2	94.0
	AvgComSales	9.86	-0.12	33.5	103.9
	Triple_Lowe	8.85	-0.06	30.1	93.4
	High_R_Tint	9.32	-0.07	31.7	98.3
	High_R_Clear	9.86	-0.06	33.6	104.0
	189.1	8.95	-0.25	30.3	94.2
	EC_Window	15.25	-0.13	51.9	160.9
	EC_HR_Window	14.08	-0.14	47.9	148.5
Phoenix	base case	8.49	-2.55	26.4	86.8
	AvgComSales	9.80	-1.73	31.7	101.5
	Triple_Lowe	8.77	-1.36	28.6	91.1
	High_R_Tint	8.90	-1.54	28.8	92.3
	High_R_Clear	9.78	-1.38	32.0	101.7
	189.1	8.64	-2.18	27.3	88.8
	EC_Window	15.34	-3.99	48.3	157.5
	EC_HR_Window	13.80	-4.50	42.6	140.7
Chicago	base case	9.59	-8.10	24.6	92.4
	AvgComSales	9.65	-7.27	25.7	94.0
	Triple_Lowe	8.78	-4.36	25.6	87.9
	High_R_Tint	9.32	-4.78	27.0	93.2
	High_R_Clear	9.72	-5.31	27.8	96.8
	189.1	9.42	-5.99	26.1	92.9
	EC_Window	13.86	-15.38	31.9	129.5
	EC_HR_Window	13.39	-14.60	31.1	125.4
Duluth	base case	9.53	-11.83	20.7	87.6
	AvgComSales	9.67	-11.64	21.3	89.3
	Triple_Lowe	8.86	-7.89	22.3	84.9
	High_R_Tint	8.89	-9.62	20.7	83.4
	High_R_Clear	9.73	-9.12	24.0	92.7
	189.1	9.72	-9.94	23.2	91.7
	EC_Window	14.94	-30.16	20.8	124.7
	EC_HR_Window	13.64	-26.10	20.4	115.5

If comparing the EC windows daylighting cases with the base case windows without daylighting, the daylighting energy savings will be much higher. The rationale of this comparison is EC windows can automatically dim the windows to reduce the glare and meet the space illuminance requirement while the base case windows could not automatically adjust windows light transmission to reduce glare.

The Impact of Orientation on Window Energy Performance

Window orientation plays a significant role in window energy performance. To quantify the impact, building energy use and savings were further calculated for each perimeter zone with different cardinal orientation. As the building is served by a central plant with chiller for cooling and boiler for heating, the cooling electricity use and heating gas use for each zone are not calculated by EnergyPlus, they were calculated by scaling the whole building cooling electricity use and heating gas use according to the ratios of the annual perimeter zone cooling and heating loads to the annual whole building cooling and heating loads, respectively. The lighting and receptacle electricity use for each zone were calculated directly by EnergyPlus based on its power density, operating schedule and space floor area. The interior shades (except for EC windows which do not have interior shades) are assumed to be on if glare index exceeds 22.

The south/north zones have a total window area of 11,516 ft², while the east/west zones have 7,678 ft². Table 24 and Table 25 summarize the energy savings per ft² of window area of the seven window types compared with the baseline window for perimeter zones without and with daylighting controls. In both tables, the cells were filled with colors: the level of green indicates relative magnitude of positive savings while the level of red indicates relative magnitude of negative savings (penalty).

From Table 24 for the no daylighting cases, the following can be observed:

- For San Francisco, the 189.1 and the EC windows show source energy savings across all four perimeter zones, while the highly insulated EC window shows source energy savings across three perimeter zones except the north zones. The existing commercial stock, the triple low-e, and the highly insulated tint windows show source energy savings only in the north zones. The greatest source energy savings are from the two EC windows in the south and west zones.

- For Miami, only the two EC windows show source energy savings in the east, south, and west zones. All other cases show source energy increase compared with the baseline window.

- For Phoenix, only the two EC windows show electricity, gas, site and source energy savings across all four perimeter zones. The south zones have the greatest electricity and source energy savings, followed by the east, west, and north zones. The triple low-e and the 189.1 windows show source energy savings across three perimeter zones except the south zones.

- For Chicago, the triple low-e, the highly insulated tint, and the two EC windows show source energy savings across the three perimeter zones except the north zones. The greatest source energy savings are for the west zones, followed by the east and the south zones. The 189.1 window shows more electricity use across all four zones, but the gas savings result in the source energy savings for the east and the west zones.

- For Duluth, only the highly insulated tint and the two EC windows show electricity, gas, and site and source energy savings across all four perimeter zones. The triple low-e and highly insulated clear windows show source energy savings across three perimeter zones except the north zones.

The greatest source energy savings are from the highly insulated EC window, followed by the EC window and the triple low-e window.

- The two EC windows show source energy savings across all five climates and four perimeter zones except the Miami north zones and the highly insulated EC window for the north zones in San Francisco and Chicago. The greatest source energy savings for the two EC windows are from the non-north zones in Duluth, Chicago, Phoenix, and San Francisco.

- The triple low-e and the highly insulated tint windows are more energy efficient than the baseline window in non-north zones in cold climates such as Duluth and Chicago.

- The 189.1 window shows better energy performance in San Francisco for all four perimeter zones, and the east and west zones in Duluth and Chicago.

Table 24 – Energy Savings per ft² of Window Area for Perimeter Zones, No Daylighting, Shades On If High Glare

		North Zones				East Zones				South Zones				West Zones			
Climates	Windows	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	-2.6	28.7	19.8	3.8	-8.4	14.2	-14.3	-72.7	-10.2	11.6	-23.3	-95.4	-8.9	19.9	-10.4	-72.0
	Triple_Lowe	-4.4	45.8	30.7	3.4	-4.5	24.1	8.9	-20.8	-4.1	14.2	0.2	-28.0	-4.2	30.1	15.8	-11.4
	High_R_Tint	-3.8	42.5	29.6	6.6	-4.6	22.6	7.0	-23.6	-4.6	13.8	-1.8	-33.1	-4.5	28.8	13.5	-15.8
	High_R_Clear	-4.8	42.6	26.3	-3.9	-9.4	22.5	-9.6	-74.9	-11.0	13.8	-23.8	-101.1	-9.8	28.7	-4.9	-72.5
	189.1	-1.6	30.7	25.4	17.0	-1.3	15.8	11.4	3.8	-0.6	11.7	9.6	6.3	-1.1	21.2	17.5	11.7
	EC_Window	-3.3	42.7	31.4	11.5	0.4	21.8	23.1	27.9	3.8	13.4	26.4	54.9	1.6	27.7	33.3	47.4
	EC_HR_Window	-4.9	46.7	30.1	-0.3	-0.2	23.8	23.0	23.6	3.6	13.7	26.0	53.0	0.9	29.8	33.0	42.3
Miami	AvgComSales	-4.5	0.0	-15.5	-47.9	-11.7	0.5	-39.3	-122.7	-11.2	0.1	-38.1	-118.2	-12.3	0.8	-41.3	-129.3
	Triple_Lowe	-2.4	0.0	-8.0	-24.9	-3.5	0.8	-11.1	-35.8	-4.9	0.1	-16.6	-51.6	-3.9	1.0	-12.2	-39.6
	High_R_Tint	-2.5	0.0	-8.5	-26.4	-4.5	0.7	-14.7	-47.1	-5.5	0.1	-18.8	-58.5	-4.4	0.9	-14.1	-45.5
	High_R_Clear	-4.7	0.0	-16.0	-49.7	-10.8	0.7	-36.2	-113.4	-11.2	0.1	-38.0	-117.9	-11.1	0.9	-37.0	-116.5
	189.1	-0.1	0.0	-0.2	-0.7	-0.1	0.0	-0.4	-1.2	-0.1	0.0	-0.5	-1.4	-0.1	0.0	-0.3	-1.1
	EC_Window	-1.4	0.0	-4.8	-15.0	1.2	0.7	4.6	13.0	1.6	0.1	5.6	17.0	0.0	0.8	0.8	0.9
	EC_HR_Window	-1.3	0.0	-4.5	-14.0	2.8	0.7	10.4	30.7	3.2	0.1	11.1	34.1	1.3	0.9	5.3	14.6
Phoenix	AvgComSales	-2.2	0.1	-7.2	-22.6	-10.5	8.7	-27.1	-101.2	-11.9	4.8	-35.8	-120.3	-10.5	11.7	-24.2	-98.5
	Triple_Lowe	0.5	0.3	2.1	6.0	-1.2	13.5	9.3	1.7	-2.9	5.7	-4.4	-25.0	-1.2	16.7	12.7	5.8
	High_R_Tint	0.3	0.2	1.1	2.9	-2.2	12.3	5.0	-9.2	-3.9	5.5	-8.0	-35.8	-2.0	15.8	9.0	-3.7
	High_R_Clear	-1.5	0.2	-4.7	-15.1	-8.6	12.8	-16.4	-76.4	-10.8	5.6	-31.1	-107.7	-8.5	16.2	-12.8	-72.1
	189.1	0.3	0.1	1.1	3.2	-0.5	5.9	4.2	1.3	-1.1	3.3	-0.4	-7.9	-0.4	7.9	6.6	4.7
	EC_Window	0.9	0.2	3.3	9.7	3.1	10.5	21.2	44.5	4.7	4.9	21.1	55.5	2.8	13.7	23.2	44.2
	EC_HR_Window	1.4	0.3	5.0	15.0	5.5	12.4	31.2	71.8	7.2	5.4	30.1	82.2	4.8	15.7	32.2	68.2
Chicago	AvgComSales	-1.5	0.0	-5.1	-15.9	-4.1	0.9	-13.1	-42.5	-5.2	3.1	-14.7	-51.7	-3.9	0.0	-13.2	-41.0
	Triple_Lowe	-1.2	0.5	-3.7	-12.3	0.8	40.5	43.1	52.2	0.4	27.7	28.9	33.9	1.7	44.7	50.7	67.2
	High_R_Tint	-1.0	0.4	-2.9	-9.8	0.5	29.8	31.6	38.0	-0.3	20.5	19.4	18.8	1.2	33.2	37.4	49.3
	High_R_Clear	-2.5	0.4	-8.1	-25.7	-3.9	35.0	21.6	-3.3	-6.0	26.5	5.9	-34.9	-3.8	36.7	23.8	0.3
	189.1	-0.9	0.2	-2.8	-9.0	-0.5	14.0	12.1	9.5	-1.7	10.1	4.3	-7.0	-0.3	15.5	14.5	13.9
	EC_Window	0.1	0.4	0.7	1.3	4.5	24.6	40.0	74.6	6.4	10.6	32.4	79.0	6.2	29.6	50.7	97.5
	EC_HR_Window	-0.8	0.6	-2.0	-7.4	5.2	43.3	61.1	102.2	6.3	23.1	44.7	92.0	6.1	49.9	70.7	118.8
Duluth	AvgComSales	-0.5	0.0	-1.8	-5.6	-0.7	-3.0	-5.4	-10.9	-1.9	-3.7	-10.3	-24.5	-0.8	-3.1	-5.8	-11.6
	Triple_Lowe	-0.2	0.8	0.2	-1.0	3.2	61.5	72.6	101.5	2.7	39.7	48.9	71.7	3.7	67.4	80.2	113.2
	High_R_Tint	0.3	0.6	1.7	4.2	3.4	44.7	56.4	85.1	2.6	27.6	36.6	58.0	3.6	49.3	61.7	92.2
	High_R_Clear	-1.1	0.6	-3.2	-11.2	-1.7	51.8	46.0	38.7	-3.6	37.5	25.2	2.9	-1.5	55.6	50.3	44.5
	189.1	-0.9	0.5	-2.5	-8.6	-2.0	41.7	34.7	24.0	-3.9	30.9	17.5	-7.8	-1.9	44.7	38.2	28.5
	EC_Window	1.1	0.6	4.3	12.1	7.3	35.1	59.9	115.2	9.4	8.7	40.7	108.6	8.8	40.6	70.6	137.4
	EC_HR_Window	0.2	1.0	1.7	3.4	7.1	67.9	92.2	149.6	9.1	32.5	63.7	132.1	8.4	75.7	104.2	170.9

Table 25 shows the energy savings for the daylighting cases. The energy savings of the daylighting cases demonstrate similar trends as the no daylighting cases, except the north zones showing more energy savings for the seven windows across all climates except Miami. Compared with the no daylighting cases, the daylighting cases show more energy savings, except:

- The two EC windows (EC_Window and EC_HR_Window) for the non-north zones in Duluth and San Francisco, and the south zones in Chicago.

- The triple low-e (Triple_Lowe) and the highly insulated tint windows (High_R_Tint) in non-north zones in Duluth and the east zones in Chicago.

Table 25 – Energy Savings per ft² of Window Area for Perimeter Zones, With Daylighting, Shades On If High Glare

		North Zones				East Zones				South Zones				West Zones			
Climates	Windows	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	-2.2	33.1	25.6	12.8	-7.8	17.6	-9.2	-63.6	-10.0	13.6	-20.6	-90.9	-8.4	23.2	-5.4	-63.3
	Triple_Lowe	-5.2	55.0	37.4	5.5	-4.6	28.6	12.8	-17.6	-4.2	16.5	2.0	-26.8	-4.5	35.3	19.9	-9.0
	High_R_Tint	-4.2	50.7	36.3	10.9	-4.6	26.5	10.8	-19.6	-4.6	16.0	0.3	-31.1	-4.6	33.3	17.6	-12.3
	High_R_Clear	-4.5	50.5	35.2	8.0	-9.0	26.5	-4.2	-66.1	-10.9	16.1	-20.9	-97.1	-9.5	33.5	1.1	-63.6
	189.1	-2.2	36.2	28.6	15.9	-1.5	18.8	13.6	4.4	-0.8	13.3	10.5	5.9	-1.5	24.1	19.2	11.0
	EC_Window	-2.8	47.5	38.1	22.7	0.2	23.3	23.9	27.2	3.2	14.8	25.9	50.4	1.2	29.8	33.9	45.1
	EC_HR_Window	-4.4	53.2	38.2	11.9	-0.6	26.2	24.2	22.5	2.8	15.0	24.6	46.2	0.3	32.8	33.7	38.5
Miami	AvgComSales	-3.3	1.9	-9.5	-33.2	-11.3	0.6	-38.0	-118.8	-10.8	0.1	-36.5	-113.4	-11.3	0.9	-37.7	-118.6
	Triple_Lowe	-2.2	3.1	-4.5	-20.2	-3.7	0.8	-11.8	-38.3	-4.8	0.2	-16.2	-50.5	-3.9	1.1	-12.1	-39.6
	High_R_Tint	-2.0	3.0	-4.0	-18.3	-4.2	0.8	-13.5	-43.2	-5.3	0.2	-17.9	-55.7	-4.1	1.1	-13.0	-42.4
	High_R_Clear	-3.5	3.0	-9.1	-34.1	-10.4	0.8	-34.6	-108.8	-10.7	0.2	-36.3	-112.7	-10.1	1.1	-33.3	-105.1
	189.1	-0.1	0.1	-0.1	-0.5	-0.1	0.0	-0.3	-1.0	-0.1	0.0	-0.4	-1.3	-0.1	0.0	-0.3	-1.0
	EC_Window	-0.2	2.8	2.0	0.5	1.6	0.7	6.3	18.1	2.2	0.1	7.8	23.9	0.8	1.0	3.6	9.2
	EC_HR_Window	-0.2	3.1	2.3	0.9	3.3	0.8	12.2	36.2	3.9	0.2	13.4	41.1	1.9	1.1	7.5	21.0
Phoenix	AvgComSales	-0.8	14.4	11.7	7.3	-9.6	10.3	-22.4	-90.0	-11.2	5.5	-32.6	-112.0	-9.3	13.0	-18.5	-83.5
	Triple_Lowe	0.8	27.4	30.2	38.4	-1.0	14.9	11.5	5.8	-2.6	6.5	-2.5	-20.8	-1.0	18.4	14.9	9.1
	High_R_Tint	0.8	24.3	27.0	34.8	-1.8	13.8	7.6	-3.9	-3.6	6.2	-6.0	-31.0	-1.7	17.4	11.7	1.3
	High_R_Clear	-0.1	24.9	24.5	26.0	-7.7	14.4	-11.7	-65.2	-10.0	6.5	-27.8	-98.9	-7.2	18.1	-6.5	-56.4
	189.1	0.4	10.1	11.4	15.3	-0.4	6.6	5.4	3.5	-0.9	3.7	0.5	-5.7	-0.3	8.5	7.3	5.8
	EC_Window	2.3	21.6	29.6	48.2	4.1	11.4	25.3	55.5	5.4	5.4	23.9	63.0	3.9	14.4	27.6	56.5
	EC_HR_Window	2.8	26.6	36.2	58.8	6.5	13.0	35.3	83.2	7.8	5.9	32.7	89.3	5.9	16.8	37.1	81.2
Chicago	AvgComSales	-1.1	-1.5	-5.3	-13.3	-4.2	1.4	-12.8	-42.6	-5.1	4.2	-13.1	-48.8	-3.9	0.8	-12.4	-39.9
	Triple_Lowe	-1.9	53.7	47.3	38.8	0.0	43.0	43.0	46.8	-0.2	30.2	29.6	31.1	1.4	48.1	52.9	67.6
	High_R_Tint	-1.3	39.8	35.3	29.6	0.0	31.8	31.7	34.4	-0.1	22.9	22.7	24.4	0.8	35.7	38.3	47.1
	High_R_Clear	-1.9	40.2	33.8	24.2	-3.9	36.8	23.4	-1.2	-5.8	29.6	9.8	-28.9	-3.7	38.9	26.3	3.4
	189.1	-0.8	18.4	15.8	12.0	-0.8	15.2	12.4	8.0	-1.7	11.5	5.5	-5.8	-0.5	17.1	15.3	13.0
	EC_Window	0.8	40.4	43.1	52.6	4.6	24.1	40.0	75.4	6.1	9.4	30.1	74.3	6.1	29.0	50.0	96.6
	EC_HR_Window	0.1	64.7	65.2	72.1	5.4	43.7	62.1	104.7	6.1	22.9	43.8	89.5	6.1	50.3	71.0	119.2
Duluth	AvgComSales	-0.4	-5.0	-6.2	-9.3	-0.6	-2.9	-5.0	-9.8	-1.8	-3.6	-9.7	-22.9	-0.7	-3.1	-5.4	-10.4
	Triple_Lowe	-0.9	82.4	79.4	80.6	2.5	64.3	72.8	96.4	2.2	42.0	49.6	69.5	2.9	70.9	80.9	108.3
	High_R_Tint	-0.5	59.9	58.3	60.5	2.8	46.2	55.7	79.8	2.3	28.5	36.2	55.0	3.0	51.4	61.5	87.5
	High_R_Clear	-0.7	63.3	60.8	61.4	-1.6	53.5	48.2	41.8	-3.3	40.6	29.1	8.9	-1.4	57.9	53.1	48.5
	189.1	-0.6	49.8	47.6	47.5	-1.9	42.8	36.4	27.0	-3.6	33.4	21.0	-2.0	-1.7	46.3	40.4	32.2
	EC_Window	1.4	55.0	60.0	75.4	7.2	31.7	56.2	110.6	8.2	3.0	30.9	89.7	8.0	36.3	63.6	124.1
	EC_HR_Window	0.9	98.8	101.9	117.3	7.2	67.0	91.7	149.6	8.5	29.6	58.7	122.3	8.1	74.9	102.6	167.5

Table 26 converts the energy savings amount in Table 25 into energy savings percentages. It can be seen from Table 26 that the seven window types have significant percentages of gas savings in all perimeter zones across all climates except the average commercial sale windows in Chicago and Duluth. Electricity savings are achieved for the two EC windows on four orientations across all five cities except the north zone in San Francisco and Miami. Site and source energy savings are mostly achieved for the north zones except Miami.

Table 26 – Energy Savings Percentages for Perimeter Zones, With Daylighting, Shades On If High Glare

Climates	Windows	North Zones				East Zones				South Zones				West Zones			
		Electricity	Gas	Site Energy	Source Energy	Electricity	Gas	Site Energy	Source Energy	Electricity	Gas	Site Energy	Source Energy	Electricity	Gas	Site Energy	Source Energy
San Francisco	AvgComSales	-10%	52%	18%	4.2%	-29%	54%	-7.3%	-19.7%	-30.4%	75.4%	-15.8%	-24.8%	-29.6%	59.4%	-4.0%	-18.5%
	Triple_Lowe	-23%	87%	27%	1.8%	-17%	89%	10.3%	-5.5%	-12.9%	92.0%	1.6%	-7.3%	-15.9%	90.2%	14.7%	-2.6%
	High_R_Tint	-19%	80%	26%	3.6%	-17%	82%	8.6%	-6.1%	-14.0%	89.2%	0.3%	-8.5%	-16.3%	85.0%	12.9%	-3.6%
	High_R_Clear	-20%	80%	25%	2.6%	-33%	82%	-3.4%	-20.5%	-33.0%	89.7%	-16.1%	-26.4%	-33.5%	85.6%	0.8%	-18.6%
	189.1	-10%	57%	21%	5.2%	-5.6%	58%	10.9%	1.4%	-2.5%	73.7%	8.0%	1.6%	-5.1%	61.7%	14.1%	3.2%
	EC_Window	-12%	75%	27%	7.5%	0.6%	72%	19.1%	8.4%	9.9%	82.2%	19.8%	13.7%	4.2%	76.2%	24.9%	13.2%
	EC_HR_Window	-20%	84%	27%	3.9%	-2.1%	81%	19.4%	7.0%	8.6%	83.2%	18.9%	12.6%	0.9%	83.9%	24.8%	11.3%
Miami	AvgComSales	-7.8%	51%	-6.3%	-7.3%	-22.0%	65%	-21.5%	-21.8%	-20.3%	87%	-20.2%	-20.3%	-22.1%	73%	-21.5%	-21.9%
	Triple_Lowe	-5.2%	82%	-3.0%	-4.4%	-7.2%	87%	-6.7%	-7.0%	-9.0%	100%	-8.9%	-9.0%	-7.5%	89%	-6.9%	-7.3%
	High_R_Tint	-4.7%	77%	-2.7%	-4.0%	-8.1%	83%	-7.6%	-7.9%	-10.0%	97%	-9.9%	-9.9%	-8.1%	87%	-7.4%	-7.8%
	High_R_Clear	-8.2%	78%	-6.0%	-7.5%	-20.2%	83%	-19.6%	-20.0%	-20.2%	100%	-20.1%	-20.1%	-19.7%	86%	-18.9%	-19.4%
	189.1	-0.1%	2.4%	-0.1%	-0.1%	-0.2%	3.2%	-0.2%	-0.2%	-0.2%	6.0%	-0.2%	-0.2%	-0.2%	2.9%	-0.2%	-0.2%
	EC_Window	-0.6%	74%	1.3%	0.1%	3.2%	78%	3.6%	3.3%	4.2%	88%	4.3%	4.3%	1.5%	81%	2.1%	1.7%
	EC_HR_Window	-0.5%	82%	1.5%	0.2%	6.5%	82%	6.9%	6.6%	7.3%	98%	7.4%	7.3%	3.7%	84%	4.3%	3.9%
Phoenix	AvgComSales	-1.8%	30%	6.0%	1.4%	-17.5%	50%	-10.8%	-15.0%	-19.3%	73%	-15.9%	-18.1%	-17.0%	57%	-8.9%	-13.9%
	Triple_Lowe	1.9%	58%	15.4%	7.5%	-1.8%	73%	5.5%	1.0%	-4.6%	86%	-1.2%	-3.4%	-1.9%	81%	7.1%	1.5%
	High_R_Tint	1.8%	52%	13.8%	6.8%	-3.3%	67%	3.7%	-0.7%	-6.2%	83%	-2.9%	-5.0%	-3.1%	76%	5.6%	0.2%
	High_R_Clear	-0.3%	53%	12.6%	5.1%	-14.0%	70%	-5.7%	-10.8%	-17.4%	86%	-13.6%	-16.0%	-13.3%	79%	-3.1%	-9.4%
	189.1	0.9%	21%	5.9%	3.0%	-0.6%	32%	2.6%	0.6%	-1.6%	49%	0.3%	-0.9%	-0.6%	37%	3.5%	1.0%
	EC_Window	5.4%	46%	15.1%	9.4%	7.4%	56%	12.2%	9.2%	9.3%	72%	11.7%	10.2%	7.1%	63%	13.2%	9.4%
	EC_HR_Window	6.5%	56%	18.5%	11.5%	11.9%	64%	17.0%	13.8%	13.6%	79%	16.0%	14.4%	10.9%	74%	17.8%	13.5%
Chicago	AvgComSales	-3.9%	-1.3%	-2.4%	-3.1%	-11.9%	1.5%	-6.0%	-9.0%	-14.0%	6.8%	-7.1%	-10.9%	-11.0%	0.8%	-5.5%	-8.2%
	Triple_Lowe	-6.6%	44.0%	21.6%	8.9%	0.0%	45.7%	20.1%	9.9%	-0.5%	49.4%	16.1%	6.9%	4.1%	46.4%	23.7%	14.0%
	High_R_Tint	-4.6%	32.7%	16.1%	6.8%	-0.1%	33.7%	14.8%	7.3%	-0.2%	37.6%	12.4%	5.5%	2.2%	34.4%	17.1%	9.7%
	High_R_Clear	-6.5%	33.0%	15.4%	5.6%	-11.2%	39.0%	10.9%	-0.3%	-16.1%	48.4%	5.3%	-6.5%	-10.5%	37.5%	11.7%	0.7%
	189.1	-2.7%	15.1%	7.2%	2.8%	-2.3%	16.1%	5.8%	1.7%	-4.8%	18.8%	3.0%	-1.3%	-1.5%	16.5%	6.8%	2.7%
	EC_Window	2.8%	33.2%	19.7%	12.1%	13.3%	25.6%	18.7%	15.9%	16.9%	15.3%	16.3%	16.6%	17.5%	28.0%	22.4%	19.9%
	EC_HR_Window	0.5%	53.1%	29.8%	16.6%	15.4%	46.4%	29.1%	22.1%	17.0%	37.6%	23.8%	20.0%	17.3%	48.5%	31.8%	24.6%
Duluth	AvgComSales	-1.4%	-2.6%	-2.2%	-1.9%	-1.9%	-1.9%	-1.9%	-1.9%	-5.2%	-3.7%	-4.5%	-4.9%	-2.0%	-1.9%	-2.0%	-2.0%
	Triple_Lowe	-3.4%	43.0%	28.3%	16.7%	7.6%	42.7%	27.9%	19.0%	6.5%	42.9%	23.0%	14.8%	8.8%	43.9%	29.4%	20.6%
	High_R_Tint	-1.8%	31.2%	20.8%	12.5%	8.6%	30.7%	21.3%	15.7%	6.5%	29.2%	16.8%	11.7%	8.9%	31.8%	22.4%	16.6%
	High_R_Clear	-2.8%	33.0%	21.7%	12.7%	-4.9%	35.6%	18.4%	8.2%	-9.7%	41.5%	13.5%	1.9%	-4.2%	35.9%	19.3%	9.2%
	189.1	-2.5%	25.9%	17.0%	9.8%	-5.8%	28.4%	13.9%	5.3%	-10.6%	34.2%	9.7%	-0.4%	-5.2%	28.7%	14.7%	6.1%
	EC_Window	5.6%	28.7%	21.4%	15.6%	22.2%	21.0%	21.5%	21.8%	23.7%	3.1%	14.4%	19.1%	24.1%	22.5%	23.1%	23.6%
	EC_HR_Window	3.4%	51.5%	36.4%	24.3%	22.3%	44.6%	35.1%	29.5%	24.7%	30.3%	27.3%	26.0%	24.4%	46.4%	37.4%	31.8%

Table 27 compares the energy savings between the daylighting (Table 25) and no daylighting (Table 24) scenarios to show the impact on energy savings if daylighting controls is deployed. The cell values were calculated as the values in Table 25 subtracting the corresponding values in Table 24. Cells are filled with the green color if the values are greater than zero, which indicates the daylighting cases have relatively higher energy savings than the no daylighting cases. Table 27 clearly shows that the energy savings of the daylighting cases are mostly higher than the no daylighting cases except the two EC windows on the non-North orientations in Duluth, Chicago, and San Francisco, and the triple low-e and High_R_tint windows on the non-North orientations in Duluth and Chicago.

Table 27 – Relative Energy Savings per ft² of Window Area for Perimeter Zones, Daylighting vs. No Daylighting

Climates	Windows	North Zones				East Zones				South Zones				West Zones			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	0.4	4.4	5.8	9.0	0.5	3.3	5.1	9.1	0.2	1.9	2.7	4.4	0.5	3.3	5.0	8.7
	Triple_Lowe	-0.8	9.2	6.6	2.1	-0.2	4.5	4.0	3.1	-0.1	2.3	1.9	1.2	-0.3	5.2	4.1	2.4
	High_R_Tint	-0.4	8.2	6.7	4.3	0.0	3.9	3.8	4.0	-0.1	2.3	2.1	2.0	-0.1	4.5	4.1	3.5
	High_R_Clear	0.3	7.8	8.9	11.9	0.4	4.0	5.4	8.8	0.1	2.3	2.8	4.1	0.3	4.8	6.0	8.9
	189.1	-0.7	5.5	3.2	-1.1	-0.3	3.0	2.1	0.6	-0.2	1.5	0.9	-0.4	-0.4	3.0	1.7	-0.7
	EC_Window	0.6	4.8	6.7	11.2	-0.2	1.6	0.8	-0.7	-0.6	1.4	-0.5	-4.5	-0.4	2.1	0.6	-2.3
	EC_HR_Window	0.5	6.5	8.1	12.2	-0.4	2.4	1.2	-1.2	-0.8	1.2	-1.4	-6.7	-0.7	3.0	0.7	-3.8
Miami	AvgComSales	1.2	1.9	6.0	14.7	0.4	0.1	1.3	3.9	0.5	0.0	1.6	4.8	1.0	0.2	3.5	10.7
	Triple_Lowe	0.1	3.1	3.5	4.7	-0.2	0.1	-0.8	-2.5	0.1	0.0	0.4	1.1	0.0	0.2	0.1	0.1
	High_R_Tint	0.5	2.9	4.5	8.1	0.4	0.1	1.3	3.9	0.3	0.0	0.9	2.8	0.3	0.2	1.1	3.1
	High_R_Clear	1.2	3.0	7.0	15.6	0.4	0.1	1.5	4.6	0.5	0.0	1.7	5.2	1.1	0.2	3.8	11.4
	189.1	0.0	0.1	0.1	0.2	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.2
	EC_Window	1.2	2.8	6.8	15.6	0.5	0.1	1.7	5.1	0.7	0.0	2.3	6.9	0.8	0.2	2.8	8.3
	EC_HR_Window	1.1	3.1	6.8	14.9	0.5	0.0	1.8	5.5	0.7	0.0	2.3	7.0	0.6	0.1	2.2	6.5
Phoenix	AvgComSales	1.4	14.2	18.9	29.9	0.9	1.6	4.6	11.2	0.7	0.7	3.2	8.3	1.3	1.3	5.7	15.0
	Triple_Lowe	0.3	27.1	28.1	32.5	0.2	1.4	2.2	4.1	0.3	0.8	1.9	4.2	0.1	1.7	2.2	3.4
	High_R_Tint	0.5	24.0	25.9	31.9	0.4	1.4	2.6	5.3	0.4	0.8	2.0	4.7	0.3	1.6	2.7	5.0
	High_R_Clear	1.3	24.7	29.3	41.2	0.9	1.6	4.7	11.3	0.7	0.8	3.4	8.8	1.3	1.9	6.3	15.7
	189.1	0.1	9.9	10.3	12.1	0.1	0.8	1.2	2.3	0.2	0.4	1.0	2.2	0.0	0.6	0.7	1.1
	EC_Window	1.4	21.4	26.3	38.6	1.0	0.9	4.2	11.1	0.7	0.6	2.8	7.5	1.1	0.7	4.4	12.3
	EC_HR_Window	1.4	26.3	31.2	43.8	1.0	0.6	4.1	11.4	0.6	0.5	2.6	7.0	1.1	1.1	4.9	12.9
Chicago	AvgComSales	0.4	-1.5	-0.2	2.5	-0.1	0.5	0.3	-0.2	0.2	1.1	1.6	2.8	0.0	0.8	0.9	1.1
	Triple_Lowe	-0.7	53.2	50.9	51.1	-0.8	2.5	-0.1	-5.4	-0.5	2.5	0.7	-2.9	-0.3	3.3	2.3	0.4
	High_R_Tint	-0.4	39.5	38.3	39.4	-0.5	1.9	0.1	-3.6	0.3	2.4	3.4	5.6	-0.5	2.5	0.9	-2.2
	High_R_Clear	0.6	39.8	41.9	49.9	0.0	1.7	1.8	2.0	0.2	3.1	3.9	6.0	0.1	2.2	2.4	3.2
	189.1	0.1	18.2	18.6	21.0	-0.3	1.2	0.3	-1.5	0.0	1.4	1.3	1.2	-0.2	1.6	0.8	-0.8
	EC_Window	0.7	40.0	42.5	51.3	0.1	-0.4	0.0	0.8	-0.3	-1.2	-2.3	-4.7	0.0	-0.5	-0.7	-0.9
	EC_HR_Window	0.9	64.1	67.2	79.6	0.2	0.4	1.0	2.4	-0.2	-0.2	-0.9	-2.5	0.0	0.3	0.3	0.4
Duluth	AvgComSales	0.2	-4.9	-4.4	-3.7	0.1	0.0	0.4	1.1	0.1	0.1	0.5	1.6	0.1	0.0	0.4	1.2
	Triple_Lowe	-0.7	81.6	79.2	81.7	-0.8	2.8	0.2	-5.1	-0.4	2.2	0.7	-2.2	-0.8	3.5	0.7	-4.9
	High_R_Tint	-0.8	59.3	56.6	56.3	-0.7	1.5	-0.7	-5.3	-0.4	0.9	-0.4	-3.0	-0.7	2.0	-0.2	-4.8
	High_R_Clear	0.4	62.7	64.0	72.6	0.1	1.8	2.1	3.1	0.3	3.0	3.9	6.0	0.1	2.3	2.8	4.0
	189.1	0.2	49.3	50.0	56.1	0.2	1.1	1.7	2.9	0.3	2.5	3.5	5.8	0.2	1.5	2.2	3.7
	EC_Window	0.4	54.4	55.7	63.3	-0.1	-3.5	-3.7	-4.6	-1.2	-5.7	-9.8	-19.0	-0.8	-4.3	-7.1	-13.2
	EC_HR_Window	0.7	97.8	100.1	113.9	0.1	-0.8	-0.5	0.0	-0.6	-2.8	-5.0	-9.8	-0.2	-0.7	-1.6	-3.4

Sensitivity Analysis

Windows energy performance is not only dependent on the window assemblies, but also varies with types of shading controls, window area, internal loads, and daylighting controls. A sensitivity analysis of these parameters would help understand and quantify their impacts on windows energy performance, and identify which window technology is more energy efficient under certain conditions. The large office building located in three typical climates, San Francisco, Phoenix, and Chicago were used in the sensitivity analysis.

In addition to the base case shading control "shades on if high glare", two more shading controls were studied: shades always on, and shades always off. The results from these two shading controls serve as the upper and lower boundaries.

Two scenarios with 10% and 80% window-wall-ratio (WWR) were studied to look at the impact of window area on window energy performance. High and low internal loads scenarios were also studied.

Table 28 summarizes the scenarios of sensitivity runs, while Table 29 to Table 46 show the whole building energy use and savings.

Table 28 – Scenarios of Sensitivity Runs

Run Description	Window-Wall-Ratio	Internal Loads (W/ft^2)	Daylighting Controls	Shading Controls
10% WWR (small window area)	10%	LPD = 1.0, EPD = 0.75 (base case)	Yes, No	Shades On If High Glare (base case)
80% WWR (large window area)	80%	LPD = 1.0, EPD = 0.75 (base case)	Yes, No	Shades On If High Glare (base case)
High internal loads	40% (base case)	LPD = 1.25, EPD =1.0	Yes, No	Shades On If High Glare (base case)
Low internal loads	40% (base case)	LPD = 0.75, EPD = 0.5	Yes, No	Shades On If High Glare (base case)
Shades Always On	40% (base case)	LPD = 1.0, EPD = 0.75 (base case)	Yes, No	Shades Always On
Shades Always Off	40% (base case)	LPD = 1.0, EPD = 0.75 (base case)	Yes, No	Shades Always Off

Simulation results are summarized in tables which also calculated the energy savings of the seven window types compared with the baseline 90.1 windows under each sensitivity scenario. For each scenario, a separate table calculated the relative energy savings compared with the corresponding base cases. From these tables (Table 29 to Table 46), the following can be observed:

- At 10% WWR without daylighting (Table 29), it is interesting to see some trend changes – for San Francisco, the 189.1 and the two EC windows show negative savings of electricity, site and source energy compared with the positive savings for the same windows at 40% WWR in Table 15. Table 30 compared the relative energy savings (Table 29 values subtracted corresponding values in Table 15) between the 10% WWR cases and the baseline 40% WWR cases. Positive values in Table 30 indicate that energy savings of the 10% WWR cases are higher than those of the 40% WWR cases, respectively; while negative values indicate relatively less savings.

- At 10% WWR with daylighting (Table 31), it is interesting to see some trend changes – for San Francisco, the source energy savings of all seven window types are reversed compared with the 40% WWR cases with daylighting (Table 16); for Phoenix, the average commercial sale windows and the High_R_Clear window show positive energy savings which are contrary to the negative savings in the 40% WWR cases; for Chicago, the Triple_Lowe and the High_R_Tint windows show negative savings which are contrary to the positive savings in the 40% WWR cases. Table 32 shows the relative energy savings between the 10% WWR cases and the 40% WWR cases. It can be seen from Table 32, all seven windows show relatively better energy performance for the 10% WWR cases in Phoenix and Chicago, while for San Francisco, only the existing commercial and the High_R_Clear windows show better energy performance than the 40% WWR cases.

- At 80% WWR without daylighting (Table 33), the energy savings trend is the same of the 40% WWR cases for three locations. Table 34 shows the relative energy savings between the 80% WWR cases and the 40% WWR cases. It can be seen from Table 34, the energy savings of the 80% WWR cases, except the existing commercial window and the highly insulated clear window in San Francisco and Chicago, show better energy savings than the 40% WWR without daylighting cases. Table 34 was calculated as the 80% WWR cases savings (Table 33) minus the 40% WWR cases savings (Table 15). The two EC windows especially have much higher energy savings for the 80% WWR cases compared with the 40% WWR cases across three locations.

- At 80% WWR with daylighting (Table 35), the energy savings trend is similar to the 40% WWR cases (Table 16) for three locations. Table 36 shows the relative energy savings between the 80% WWR cases and the 40% WWR cases. It can be seen Table 36, the energy savings of the 80% WWR cases with daylighting, except the existing commercial window and the highly insulated clear window in all three locations, show better energy savings than the 40% WWR cases with daylighting. The two EC windows especially show much higher energy savings for the 80% WWR cases compared with the 40% WWR cases across three locations.

- At high internal loads without daylighting (Table 37), the trend is consistent that all energy savings decrease as can be seen from Table 38 which shows the relative energy savings between the high internal loads and the base cases.

- At high internal loads with daylighting (Table 39 and Table 40), the trend is similar to the no daylighting cases – energy savings decrease.

- At low internal loads without daylighting (Table 41 and Table 42), gas savings increase for all cases. The source energy savings increase for all cases in San Francisco and Chicago, and in Phoenix except the Triple_Lowe and the two EC windows cases.

- At low internal loads with daylighting (Table 43 and Table 44), all cases, except the highly insulated tint window in Phoenix, show better energy savings than the base cases.

- The impacts of shading controls on window energy savings are summarized in Table 45 for no daylighting cases and Table 46 for daylighting cases. From Table 45, it can be seen that for the no daylighting cases, only the existing commercial window with shades always on in all three climates, and the highly insulated clear window with shades always on in San Francisco and Phoenix show more energy savings than the base cases with shades on if high glare. Shades always off show significant less energy savings than the base cases for the two EC windows for all three locations. Other cases show very small differences in energy savings. For daylighting cases listed in Table 46, the results are similar to the no daylighting cases for shades always on. For shades always off, the differences in energy savings are very small for all windows in all three locations.

Table 29 – Whole Building Energy Use and Savings (10% WWR, Shades On If High Glare, No Daylighting)

Climates	Windows	Energy Savings per ft² of Window Area						Whole Building Energy Use			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,043,319	8,234	18,023	54,132
	AvgComSales	-4.7	18.8	2.8	0.1%	-29.1	-0.5%	5,088,356	6,432	17,996	54,411
	Triple_Lowe	-6.3	19.1	-2.3	-0.1%	-45.4	-0.8%	5,103,619	6,402	18,045	54,568
	High_R_Tint	-5.7	18.1	-1.3	-0.1%	-40.3	-0.7%	5,098,006	6,494	18,035	54,519
	High_R_Clear	-6.9	23.5	0.0	0.0%	-47.1	-0.8%	5,109,531	5,975	18,023	54,584
	189.1	-3.3	10.0	-1.5	-0.1%	-24.3	-0.4%	5,075,317	7,278	18,037	54,365
	EC_Window	-5.2	16.5	-1.1	-0.1%	-36.7	-0.7%	5,093,041	6,648	18,034	54,484
	EC_HR_Window	-6.3	18.1	-3.5	-0.2%	-47.2	-0.8%	5,104,167	6,496	18,057	54,585
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,452,139	8,699	22,874	69,053
	AvgComSales	-5.0	14.4	-2.8	-0.1%	-37.4	-0.5%	6,500,406	7,320	22,901	69,412
	Triple_Lowe	-0.2	17.1	16.3	0.7%	16.2	0.2%	6,454,364	7,059	22,718	68,898
	High_R_Tint	-1.0	15.9	12.6	0.5%	7.3	0.1%	6,461,319	7,173	22,753	68,983
	High_R_Clear	-3.8	19.0	5.9	0.2%	-19.7	-0.3%	6,488,869	6,875	22,817	69,242
	189.1	-0.2	7.0	6.4	0.3%	5.7	0.1%	6,453,886	8,027	22,813	68,998
	EC_Window	0.3	15.7	16.8	0.7%	20.5	0.3%	6,449,067	7,188	22,713	68,856
	EC_HR_Window	1.6	17.8	23.3	1.0%	36.5	0.5%	6,436,672	6,987	22,650	68,703
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,401,728	33,042	21,726	60,624
	AvgComSales	-1.9	5.0	-1.4	-0.1%	-14.1	-0.2%	5,419,511	32,560	21,739	60,759
	Triple_Lowe	0.1	38.1	38.6	1.7%	43.1	0.7%	5,400,394	29,382	21,356	60,210
	High_R_Tint	0.0	28.9	29.0	1.3%	31.7	0.5%	5,401,642	30,267	21,448	60,320
	High_R_Clear	-1.9	39.0	32.4	1.4%	22.2	0.4%	5,420,295	29,296	21,415	60,411
	189.1	-0.5	14.5	12.7	0.6%	10.1	0.2%	5,406,914	31,649	21,604	60,527
	EC_Window	0.6	28.0	30.1	1.3%	37.1	0.6%	5,395,850	30,353	21,437	60,268
	EC_HR_Window	0.9	46.6	49.7	2.2%	60.4	1.0%	5,393,075	28,568	21,249	60,044

Table 30 – Relative Energy Savings, 10% vs. 40% WWR, Shades On If High Glare, No Daylighting

Climates	Windows	Relative Energy Savings per ft² of Window Area			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	1.6	0.0	5.5	17.0
	Triple_Lowe	-4.2	-9.6	-23.9	-54.9
	High_R_Tint	-3.3	-8.8	-20.2	-44.8
	High_R_Clear	-0.2	-3.3	-3.9	-5.4
	189.1	-3.3	-10.1	-21.6	-46.3
	EC_Window	-7.8	-9.9	-36.4	-92.7
	EC_HR_Window	-8.0	-10.0	-37.3	-95.1
Phoenix	AvgComSales	3.0	4.5	14.6	36.2
	Triple_Lowe	0.1	1.6	2.0	3.0
	High_R_Tint	0.1	1.6	2.0	3.1
	High_R_Clear	2.5	4.3	12.8	30.8
	189.1	0.0	0.2	0.3	0.4
	EC_Window	-2.7	2.9	-6.3	-25.1
	EC_HR_Window	-2.8	2.9	-6.8	-26.8
Chicago	AvgComSales	2.0	4.6	11.5	26.6
	Triple_Lowe	-2.2	-2.0	-9.6	-25.7
	High_R_Tint	-1.4	-0.5	-5.2	-15.2
	High_R_Clear	0.7	5.2	7.5	12.8
	189.1	-0.2	0.9	0.4	-0.9
	EC_Window	-4.7	2.4	-13.8	-47.5
	EC_HR_Window	-4.9	3.0	-13.6	-48.1

Table 31 – Whole Building Energy Use and Savings (10% WWR, Shades On If High Glare, Daylighting)

Climates	Windows	Energy Savings per ft² of Window Area						Whole Building Energy Use			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4,877,658	9,517	17,586	52,524
	AvgComSales	-1.2	20.2	15.9	0.9%	9.1	0.2%	4,889,450	7,580	17,433	52,437
	Triple_Lowe	-9.4	24.6	-7.4	-0.4%	-71.9	-1.3%	4,967,461	7,157	17,657	53,214
	High_R_Tint	-7.6	22.7	-3.3	-0.2%	-55.5	-1.0%	4,950,692	7,341	17,618	53,057
	High_R_Clear	-4.5	27.1	11.6	0.6%	-18.3	-0.3%	4,921,217	6,918	17,475	52,700
	189.1	-6.5	13.9	-8.4	-0.5%	-53.9	-1.0%	4,940,467	8,186	17,667	53,041
	EC_Window	-1.0	14.7	11.3	0.6%	5.4	0.1%	4,887,328	8,107	17,478	52,472
	EC_HR_Window	-3.3	17.7	6.5	0.4%	-15.3	-0.3%	4,909,181	7,819	17,524	52,671
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,296,778	9,160	22,390	67,464
	AvgComSales	2.7	13.2	22.4	1.0%	42.9	0.6%	6,270,822	7,895	22,175	67,052
	Triple_Lowe	-0.1	17.8	17.5	0.8%	18.5	0.3%	6,297,697	7,448	22,222	67,286
	High_R_Tint	0.6	16.2	18.1	0.8%	24.0	0.3%	6,291,117	7,605	22,216	67,234
	High_R_Clear	2.3	18.4	26.3	1.1%	44.7	0.6%	6,274,375	7,398	22,138	67,035
	189.1	0.0	7.3	7.2	0.3%	7.6	0.1%	6,297,164	8,457	22,321	67,391
	EC_Window	8.3	13.7	42.0	1.8%	102.5	1.5%	6,217,195	7,842	21,987	66,480
	EC_HR_Window	8.1	16.2	43.8	1.9%	103.1	1.5%	6,219,192	7,605	21,970	66,475
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,195,597	34,792	21,198	58,640
	AvgComSales	-1.1	5.5	1.9	0.1%	-5.2	-0.1%	5,205,881	34,262	21,180	58,690
	Triple_Lowe	-6.7	45.5	22.7	1.0%	-20.8	-0.3%	5,259,736	30,426	20,980	58,840
	High_R_Tint	-5.5	35.0	16.0	0.7%	-20.3	-0.3%	5,248,792	31,437	21,044	58,835
	High_R_Clear	-2.7	41.8	32.6	1.5%	17.4	0.3%	5,221,350	30,779	20,885	58,473
	189.1	-3.5	18.1	6.3	0.3%	-16.8	-0.3%	5,228,892	33,052	21,138	58,801
	EC_Window	2.2	27.2	34.7	1.6%	52.9	0.9%	5,174,556	32,180	20,865	58,132
	EC_HR_Window	1.1	46.6	50.5	2.3%	63.0	1.0%	5,184,667	30,316	20,713	58,035

Table 32 – Relative Energy Savings, 10% vs. 40% WWR, Shades On If High Glare, Daylighting

Climates	Windows	Relative Energy Savings per ft² of Window Area			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	4.6	-1.8	13.8	46.7
	Triple_Lowe	-7.1	-9.3	-33.5	-84.7
	High_R_Tint	-5.2	-9.0	-26.8	-64.7
	High_R_Clear	1.8	-4.5	1.5	13.7
	189.1	-6.2	-9.4	-30.7	-76.0
	EC_Window	-3.3	-14.0	-25.1	-49.6
	EC_HR_Window	-4.5	-12.9	-28.2	-61.1
Phoenix	AvgComSales	9.4	2.5	34.8	102.5
	Triple_Lowe	0.0	1.2	1.3	1.6
	High_R_Tint	1.3	0.9	5.2	14.5
	High_R_Clear	7.4	2.5	27.7	80.7
	189.1	0.0	0.2	0.3	0.5
	EC_Window	4.3	0.7	15.4	46.3
	EC_HR_Window	2.7	1.0	10.1	29.4
Chicago	AvgComSales	2.8	4.3	13.8	34.2
	Triple_Lowe	2.0	44.6	51.3	69.6
	High_R_Tint	-1.7	33.6	27.9	19.2
	High_R_Clear	1.2	40.5	44.5	57.0
	189.1	5.0	16.8	33.8	71.1
	EC_Window	2.3	27.2	34.9	53.7
	EC_HR_Window	0.9	45.4	48.6	59.7

Table 33 – Whole Building Energy Use and Savings (80% WWR, Shades On If High Glare, No Daylighting)

Climates	Windows	Energy Savings per ft² of Window Area						Whole Building Energy Use			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,433,039	31,547	21,683	60,791
	AvgComSales	-6.9	17.5	-6.1	-2.2%	-54.1	-6.8%	5,965,645	18,097	22,155	64,944
	Triple_Lowe	-1.7	32.9	27.2	9.6%	18.3	2.3%	5,561,791	6,263	19,594	59,389
	High_R_Tint	-2.0	30.3	23.7	8.4%	12.5	1.6%	5,583,164	8,263	19,867	59,833
	High_R_Clear	-7.2	28.4	3.9	1.4%	-44.8	-5.7%	5,984,920	9,729	21,384	64,234
	189.1	0.6	21.8	23.9	8.5%	30.5	3.8%	5,384,303	14,841	19,847	58,453
	EC_Window	3.8	30.4	43.4	15.4%	73.5	9.3%	5,139,628	8,226	18,351	55,148
	EC_HR_Window	5.2	34.8	52.5	18.6%	92.9	11.7%	5,033,914	4,815	17,649	53,659
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,826,942	17,660	25,048	73,988
	AvgComSales	-7.1	10.5	-13.6	-4.2%	-63.2	-6.6%	7,370,564	9,588	26,095	78,844
	Triple_Lowe	1.1	17.4	21.2	6.5%	30.6	3.2%	6,742,805	4,280	23,424	71,639
	High_R_Tint	-0.1	16.0	15.7	4.8%	16.6	1.7%	6,833,261	5,375	23,842	72,713
	High_R_Clear	-5.2	15.9	-2.0	-0.6%	-38.1	-3.9%	7,229,878	5,471	25,204	76,910
	189.1	0.9	8.2	11.2	3.4%	18.2	1.9%	6,758,942	11,402	24,191	72,587
	EC_Window	7.5	15.9	41.4	12.7%	96.2	10.0%	6,253,911	5,435	21,872	66,604
	EC_HR_Window	9.8	18.1	51.5	15.8%	123.1	12.8%	6,075,216	3,744	21,093	64,534
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,119,508	61,463	27,016	71,304
	AvgComSales	-4.2	-0.4	-14.8	-4.2%	-45.1	-4.9%	6,444,581	61,751	28,154	74,767
	Triple_Lowe	2.8	40.6	50.1	14.3%	73.9	8.0%	5,903,933	30,315	23,166	65,627
	High_R_Tint	2.0	30.4	37.1	10.5%	53.9	5.8%	5,968,800	38,115	24,167	67,164
	High_R_Clear	-2.7	32.3	23.0	6.5%	6.6	0.7%	6,327,975	36,680	25,249	70,798
	189.1	-0.1	14.2	13.9	4.0%	14.6	1.6%	6,126,628	50,532	25,947	70,186
	EC_Window	8.5	28.5	57.3	16.3%	120.4	13.0%	5,470,003	39,601	22,615	62,061
	EC_HR_Window	9.8	47.5	81.0	23.0%	155.6	16.8%	5,365,030	25,005	20,797	59,359

Table 34 – Relative Energy Savings, 80% vs. 40% WWR, Shades On If High Glare, No Daylighting

Climates	Windows	Relative Energy Savings per ft² of Window Area			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	-0.6	-1.2	-3.4	-8.1
	Triple_Lowe	0.4	4.2	5.6	8.8
	High_R_Tint	0.4	3.4	4.7	8.0
	High_R_Clear	-0.5	1.6	0.0	-3.2
	189.1	0.6	1.7	3.8	8.4
	EC_Window	1.3	3.9	8.2	17.5
	EC_HR_Window	3.6	6.7	18.8	45.0
Phoenix	AvgComSales	0.9	0.6	3.7	10.3
	Triple_Lowe	1.4	2.0	6.9	17.4
	High_R_Tint	1.0	1.7	5.1	12.4
	High_R_Clear	1.1	1.2	4.8	12.5
	189.1	1.1	1.4	5.1	13.0
	EC_Window	4.5	3.1	18.3	50.6
	EC_HR_Window	5.3	3.2	21.4	59.8
Chicago	AvgComSales	-0.3	-0.8	-2.0	-4.5
	Triple_Lowe	0.4	0.5	2.0	5.1
	High_R_Tint	0.6	1.0	2.9	7.0
	High_R_Clear	-0.1	-1.6	-1.9	-2.8
	189.1	0.3	0.6	1.6	3.5
	EC_Window	3.1	2.8	13.4	35.8
	EC_HR_Window	4.1	3.8	17.7	47.1

Table 35 – Whole Building Energy Use and Savings (80% WWR, Shades On If High Glare, Daylighting)

Climates	Windows	Energy Savings per ft² of Window Area						Whole Building Energy Use			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,079,006	34,446	20,766	57,371
	AvgComSales	-6.7	19.1	-3.6	-1.3%	-49.6	-6.6%	5,591,694	19,752	21,045	61,178
	Triple_Lowe	-1.7	36.0	30.2	11.2%	21.6	2.9%	5,207,686	6,834	18,444	55,714
	High_R_Tint	-1.9	33.0	26.4	9.8%	15.7	2.1%	5,226,533	9,148	18,739	56,166
	High_R_Clear	-6.9	31.2	7.7	2.8%	-38.6	-5.2%	5,607,161	10,530	20,176	60,334
	189.1	0.7	23.0	25.4	9.4%	32.7	4.4%	5,024,169	16,785	18,813	54,864
	EC_Window	3.8	32.1	45.2	16.7%	75.5	10.1%	4,784,856	9,801	17,298	51,575
	EC_HR_Window	4.9	37.3	54.0	20.0%	92.4	12.4%	4,703,755	5,782	16,620	50,280
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,426,178	18,405	23,756	69,839
	AvgComSales	-7.1	10.6	-13.5	-4.4%	-63.0	-6.9%	6,968,617	10,254	24,791	74,674
	Triple_Lowe	1.0	17.9	21.2	6.9%	29.9	3.3%	6,351,072	4,651	22,125	67,544
	High_R_Tint	-0.2	16.3	15.7	5.1%	15.8	1.7%	6,441,097	5,875	22,554	68,628
	High_R_Clear	-5.2	16.3	-1.5	-0.5%	-37.1	-4.1%	6,825,053	5,923	23,868	72,686
	189.1	0.6	8.0	10.1	3.3%	15.2	1.7%	6,378,922	12,279	22,982	68,671
	EC_Window	7.2	16.0	40.6	13.1%	93.6	10.3%	5,872,189	6,135	20,640	62,652
	EC_HR_Window	9.4	18.4	50.5	16.3%	119.6	13.2%	5,702,025	4,297	19,876	60,655
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,742,325	64,892	26,073	67,697
	AvgComSales	-4.2	0.0	-14.3	-4.2%	-44.1	-5.0%	6,062,403	64,929	27,168	71,080
	Triple_Lowe	2.8	42.4	51.8	15.3%	75.4	8.5%	5,531,139	32,311	22,094	61,910
	High_R_Tint	1.9	31.9	38.5	11.3%	55.3	6.3%	5,593,083	40,413	23,116	63,449
	High_R_Clear	-2.6	33.9	25.1	7.4%	9.7	1.1%	5,941,106	38,845	24,146	66,951
	189.1	-0.1	14.9	14.4	4.3%	14.9	1.7%	5,752,064	53,477	24,964	66,553
	EC_Window	8.4	28.2	57.1	16.8%	120.0	13.6%	5,093,708	43,207	21,692	58,483
	EC_HR_Window	9.8	48.4	81.8	24.1%	156.3	17.7%	4,990,245	27,718	19,790	55,700

Table 36 – Relative Energy Savings, 80% vs. 40% WWR, Shades On If High Glare, Daylighting

Climates	Windows	Relative Energy Savings per ft² of Window Area			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	-0.8	-2.9	-5.7	-12.0
	Triple_Lowe	0.6	2.0	4.1	8.8
	High_R_Tint	0.5	1.3	2.9	6.6
	High_R_Clear	-0.6	-0.4	-2.4	-6.6
	189.1	1.0	-0.3	3.2	10.5
	EC_Window	1.6	3.5	8.8	20.4
	EC_HR_Window	3.7	6.7	19.4	46.5
Phoenix	AvgComSales	-0.3	0.0	-1.1	-3.5
	Triple_Lowe	1.1	1.3	5.0	12.9
	High_R_Tint	0.5	1.0	2.7	6.3
	High_R_Clear	-0.1	0.4	-0.1	-1.1
	189.1	0.7	0.8	3.2	8.2
	EC_Window	3.2	2.9	14.0	37.4
	EC_HR_Window	4.0	3.2	16.9	46.0
Chicago	AvgComSales	-0.3	-1.3	-2.3	-4.7
	Triple_Lowe	1.2	-1.3	2.8	11.2
	High_R_Tint	0.9	-0.7	2.3	8.3
	High_R_Clear	-0.1	-2.5	-2.7	-3.5
	189.1	0.4	-0.6	0.9	4.0
	EC_Window	3.2	2.8	13.8	37.0
	EC_HR_Window	4.1	3.9	18.0	47.8

Table 37 – Whole Building Energy Use and Savings (high internal loads, Shades On If High Glare, No Daylighting)

Climates	Windows	Energy Savings per ft² of Window Area						Whole Building Energy Use			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,470,719	13,333	23,401	69,755
	AvgComSales	-6.9	14.1	-9.5	-1.6%	-57.8	-3.2%	6,736,861	7,917	23,767	71,973
	Triple_Lowe	-2.2	22.3	14.7	2.4%	0.8	0.0%	6,556,122	4,778	22,837	69,723
	High_R_Tint	-3.0	20.8	10.5	1.7%	-9.1	-0.5%	6,586,495	5,351	22,998	70,106
	High_R_Clear	-7.6	20.7	-5.2	-0.8%	-57.4	-3.2%	6,761,553	5,396	23,599	71,958
	189.1	-0.5	15.5	13.9	2.3%	12.0	0.7%	6,488,336	7,393	22,867	69,293
	EC_Window	0.9	19.4	22.5	3.7%	30.8	1.7%	6,435,722	5,893	22,538	68,573
	EC_HR_Window	-0.3	20.6	19.6	3.2%	19.4	1.1%	6,481,825	5,425	22,648	69,009
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	7,871,258	9,609	27,805	84,131
	AvgComSales	-8.5	8.8	-20.2	-2.8%	-80.1	-3.7%	8,197,547	6,220	28,579	87,205
	Triple_Lowe	-1.0	13.8	10.4	1.4%	4.6	0.2%	7,909,167	4,315	27,405	83,954
	High_R_Tint	-1.6	12.8	7.2	1.0%	-3.3	-0.2%	7,934,070	4,707	27,529	84,259
	High_R_Clear	-6.9	13.2	-10.4	-1.4%	-58.7	-2.7%	8,136,870	4,554	28,205	86,383
	189.1	-0.4	6.1	4.6	0.6%	2.2	0.1%	7,887,600	7,269	27,627	84,048
	EC_Window	2.6	11.8	20.7	2.9%	40.2	1.8%	7,771,644	5,081	27,012	82,586
	EC_HR_Window	4.0	13.7	27.4	3.8%	57.3	2.6%	7,717,242	4,363	26,755	81,933
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,995,400	37,191	27,576	77,899
	AvgComSales	-3.7	0.0	-12.7	-1.8%	-39.3	-1.9%	7,138,339	37,195	28,064	79,408
	Triple_Lowe	1.9	36.5	43.1	6.0%	60.3	3.0%	6,921,208	23,172	25,921	75,585
	High_R_Tint	1.8	27.9	33.9	4.7%	49.1	2.4%	6,927,783	26,464	26,273	76,014
	High_R_Clear	-2.7	30.6	21.4	3.0%	4.9	0.2%	7,099,122	25,457	26,756	77,712
	189.1	-0.4	12.6	11.1	1.6%	9.4	0.5%	7,011,047	32,372	27,148	77,538
	EC_Window	4.5	23.5	38.7	5.4%	72.7	3.6%	6,824,172	28,173	26,090	75,107
	EC_HR_Window	4.8	39.8	56.3	7.8%	94.5	4.7%	6,809,736	21,916	25,415	74,271

Table 38 – Relative Energy Savings, high vs. normal internal loads, Shades On If High Glare, No Daylighting

Climates	Windows	Relative Energy Savings per ft² of Window Area			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	-0.6	-4.6	-6.8	-11.7
	Triple_Lowe	-0.2	-6.4	-6.9	-8.6
	High_R_Tint	-0.6	-6.2	-8.4	-13.6
	High_R_Clear	-0.9	-6.1	-9.1	-15.7
	189.1	-0.5	-4.6	-6.2	-10.0
	EC_Window	-1.7	-7.1	-12.7	-25.2
	EC_HR_Window	-1.9	-7.6	-14.1	-28.5
Phoenix	AvgComSales	-0.5	-1.1	-2.8	-6.5
	Triple_Lowe	-0.6	-1.7	-3.8	-8.5
	High_R_Tint	-0.6	-1.5	-3.4	-7.5
	High_R_Clear	-0.6	-1.5	-3.6	-8.1
	189.1	-0.2	-0.7	-1.4	-3.1
	EC_Window	-0.4	-1.1	-2.4	-5.4
	EC_HR_Window	-0.4	-1.3	-2.8	-6.0
Chicago	AvgComSales	0.2	-0.5	0.1	1.3
	Triple_Lowe	-0.4	-3.6	-5.1	-8.5
	High_R_Tint	0.4	-1.5	-0.3	2.2
	High_R_Clear	-0.1	-3.3	-3.6	-4.5
	189.1	0.0	-1.0	-1.2	-1.6
	EC_Window	-0.9	-2.1	-5.2	-11.8
	EC_HR_Window	-0.9	-3.8	-7.0	-14.0

Table 39 – Whole Building Energy Use and Savings (high internal loads, Shades On If High Glare, Daylighting)

Climates	Windows	Energy Savings per ft² of Window Area						Whole Building Energy Use			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,058,586	15,762	22,238	65,670
	AvgComSales	-6.3	17.1	-4.5	-0.8%	-48.2	-2.8%	6,301,855	9,180	22,410	67,519
	Triple_Lowe	-2.8	27.1	17.5	3.0%	-0.2	0.0%	6,166,959	5,355	21,567	65,678
	High_R_Tint	-2.3	25.8	18.0	3.1%	4.0	0.2%	6,146,636	5,846	21,547	65,517
	High_R_Clear	-7.0	25.3	1.5	0.3%	-46.0	-2.7%	6,326,367	6,046	22,180	67,436
	189.1	-0.6	18.9	17.0	2.9%	14.8	0.9%	6,079,792	8,503	21,585	65,102
	EC_Window	0.4	20.7	22.1	3.8%	26.7	1.6%	6,043,783	7,799	21,391	64,645
	EC_HR_Window	-0.9	22.2	19.3	3.3%	15.2	0.9%	6,091,289	7,251	21,499	65,086
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	7,472,522	10,783	26,562	80,051
	AvgComSales	-6.9	9.7	-13.8	-2.0%	-62.2	-3.0%	7,737,378	7,044	27,092	82,438
	Triple_Lowe	-0.7	15.4	13.0	1.9%	9.5	0.5%	7,499,119	4,884	26,063	79,687
	High_R_Tint	-1.2	14.1	10.1	1.5%	3.2	0.2%	7,516,981	5,374	26,173	79,930
	High_R_Clear	-5.4	14.6	-3.9	-0.6%	-41.2	-2.0%	7,680,394	5,180	26,711	81,633
	189.1	-0.2	6.7	5.9	0.9%	5.0	0.2%	7,480,739	8,221	26,334	79,858
	EC_Window	3.8	12.1	25.0	3.6%	53.1	2.5%	7,327,458	6,138	25,603	78,013
	EC_HR_Window	5.1	14.2	31.5	4.6%	69.2	3.3%	7,277,333	5,339	25,352	77,396
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	6,528,519	39,839	26,249	73,260
	AvgComSales	-3.8	-0.1	-13.1	-1.9%	-40.5	-2.1%	6,675,553	39,860	26,752	74,814
	Triple_Lowe	0.1	38.4	38.8	5.7%	43.0	2.3%	6,524,750	25,090	24,761	71,609
	High_R_Tint	0.2	29.1	29.9	4.4%	34.0	1.8%	6,520,753	28,650	25,103	71,956
	High_R_Clear	-2.8	32.0	22.3	3.3%	4.9	0.3%	6,637,864	27,549	25,393	73,072
	189.1	-0.7	13.7	11.2	1.6%	7.1	0.4%	6,557,267	34,575	25,820	72,988
	EC_Window	4.1	22.3	36.1	5.3%	67.2	3.5%	6,372,342	31,298	24,862	70,679
	EC_HR_Window	4.4	39.5	54.6	8.0%	89.9	4.7%	6,358,547	24,672	24,152	69,810

Table 40 – Relative Energy Savings, high vs. normal internal loads, Shades On If High Glare, Daylighting

Climates	Windows	Relative Energy Savings per ft² of Window Area			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	-0.5	-4.8	-6.6	-10.6
	Triple_Lowe	-0.5	-6.8	-8.6	-13.0
	High_R_Tint	0.1	-5.8	-5.5	-5.1
	High_R_Clear	-0.7	-6.3	-8.6	-14.0
	189.1	-0.2	-4.4	-5.2	-7.3
	EC_Window	-1.9	-7.9	-14.3	-28.3
	EC_HR_Window	-2.0	-8.5	-15.4	-30.6
Phoenix	AvgComSales	-0.2	-0.9	-1.5	-2.7
	Triple_Lowe	-0.6	-1.3	-3.3	-7.5
	High_R_Tint	-0.5	-1.2	-2.8	-6.4
	High_R_Clear	-0.4	-1.2	-2.5	-5.2
	189.1	-0.1	-0.5	-1.0	-2.0
	EC_Window	-0.2	-0.9	-1.6	-3.1
	EC_HR_Window	-0.3	-1.0	-2.1	-4.5
Chicago	AvgComSales	0.0	-1.3	-1.2	-1.1
	Triple_Lowe	-1.5	-5.3	-10.3	-21.2
	High_R_Tint	-0.9	-3.4	-6.4	-13.1
	High_R_Clear	-0.3	-4.4	-5.5	-8.4
	189.1	-0.2	-1.8	-2.4	-3.8
	EC_Window	-1.2	-3.2	-7.1	-15.7
	EC_HR_Window	-1.2	-5.0	-9.2	-18.6

Table 41 – Whole Building Energy Use and Savings (low internal loads, Shades On If High Glare, No Daylighting)

Climates	Windows	Energy Savings per ft² of Window Area						Whole Building Energy Use			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3,818,992	19,987	15,023	42,493
	AvgComSales	-5.7	23.9	4.5	1.1%	-34.0	-3.1%	4,037,447	10,818	14,851	43,797
	Triple_Lowe	-1.0	36.7	33.3	8.5%	29.5	2.7%	3,857,239	5,913	13,746	41,359
	High_R_Tint	-1.3	34.2	29.7	7.6%	23.4	2.1%	3,869,847	6,848	13,882	41,595
	High_R_Clear	-5.5	34.3	15.4	3.9%	-20.9	-1.9%	4,031,214	6,826	14,431	43,295
	189.1	0.8	24.5	27.4	7.0%	35.5	3.2%	3,787,508	10,565	13,973	41,131
	EC_Window	3.1	32.9	43.3	11.1%	68.3	6.2%	3,701,270	7,359	13,359	39,871
	EC_HR_Window	4.0	37.3	50.9	13.0%	82.8	7.5%	3,665,922	5,662	13,068	39,313
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,057,650	12,759	18,524	54,778
	AvgComSales	-7.2	11.8	-12.8	-2.6%	-63.1	-4.4%	5,334,339	8,221	19,014	57,202
	Triple_Lowe	-23.5	17.5	-62.6	-13.0%	-228.7	-16.0%	5,959,203	6,033	20,926	63,559
	High_R_Tint	0.0	16.2	16.0	3.3%	17.2	1.2%	5,059,353	6,537	17,908	54,116
	High_R_Clear	-5.4	17.1	-1.2	-0.2%	-37.9	-2.7%	5,263,175	6,205	18,570	56,231
	189.1	0.6	7.8	9.9	2.1%	15.1	1.1%	5,034,139	9,747	18,143	54,200
	EC_Window	-19.3	14.6	-51.2	-10.6%	-187.7	-13.2%	5,798,225	7,152	20,489	61,982
	EC_HR_Window	-17.4	16.9	-42.4	-8.8%	-165.0	-11.6%	5,724,836	6,289	20,153	61,113
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4,238,853	52,799	19,736	50,507
	AvgComSales	-3.7	2.6	-10.1	-2.0%	-36.5	-2.8%	4,381,853	51,817	20,125	51,909
	Triple_Lowe	2.6	44.8	53.8	10.5%	76.8	5.8%	4,137,333	35,594	17,669	47,557
	High_R_Tint	1.9	33.6	40.2	7.8%	57.1	4.3%	4,164,550	39,910	18,194	48,316
	High_R_Clear	-2.3	39.9	32.0	6.2%	19.1	1.5%	4,327,522	37,495	18,508	49,772
	189.1	-0.1	16.0	15.6	3.0%	16.1	1.2%	4,243,806	46,651	19,138	49,888
	EC_Window	6.3	26.2	47.9	9.3%	95.5	7.3%	3,995,683	42,726	17,899	46,841
	EC_HR_Window	7.1	47.9	72.1	14.0%	127.1	9.7%	3,966,817	34,398	16,968	45,627

Table 42 – Relative Energy Savings, low vs. normal internal loads, Shades On If High Glare, No Daylighting

Climates	Windows	Relative Energy Savings per ft² of Window Area			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	0.6	5.1	7.2	12.1
	Triple_Lowe	1.1	8.0	11.6	20.1
	High_R_Tint	1.0	7.3	10.8	18.9
	High_R_Clear	1.2	7.5	11.5	20.8
	189.1	0.8	4.5	7.2	13.4
	EC_Window	0.5	6.4	8.1	12.3
	EC_HR_Window	2.4	9.2	17.2	34.9
Phoenix	AvgComSales	0.8	1.9	4.6	10.4
	Triple_Lowe	-23.1	2.1	-76.8	-241.9
	High_R_Tint	1.0	1.9	5.4	13.1
	High_R_Clear	1.0	2.4	5.6	12.7
	189.1	0.8	1.1	3.9	9.8
	EC_Window	-22.3	1.7	-74.3	-233.3
	EC_HR_Window	-21.8	1.9	-72.6	-228.3
Chicago	AvgComSales	0.2	2.1	2.7	4.1
	Triple_Lowe	0.3	4.7	5.7	8.0
	High_R_Tint	0.5	4.1	6.0	10.2
	High_R_Clear	0.3	6.0	7.1	9.7
	189.1	0.2	2.4	3.2	5.1
	EC_Window	1.0	0.6	4.0	10.9
	EC_HR_Window	1.3	4.3	8.8	18.6

Table 43 – Whole Building Energy Use and Savings (low internal loads, Shades On If High Glare, Daylighting)

Climates	Windows	Energy Savings per ft² of Window Area						Whole Building Energy Use			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3,562,397	22,326	14,382	40,040
	AvgComSales	-5.4	26.5	8.2	2.2%	-27.6	-2.6%	3,768,222	12,154	14,066	41,101
	Triple_Lowe	-1.4	41.3	36.7	9.8%	30.6	2.9%	3,615,264	6,456	12,975	38,865
	High_R_Tint	-1.6	38.4	33.0	8.8%	25.2	2.4%	3,623,269	7,574	13,114	39,071
	High_R_Clear	-5.4	38.6	20.2	5.4%	-14.8	-1.4%	3,769,683	7,517	13,608	40,610
	189.1	0.3	26.8	27.7	7.4%	32.2	3.1%	3,551,753	12,044	13,317	38,804
	EC_Window	3.1	35.4	46.2	12.3%	71.9	6.9%	3,441,683	8,724	12,610	37,280
	EC_HR_Window	3.4	39.9	51.5	13.7%	79.5	7.6%	3,431,739	7,023	12,406	36,989
Phoenix	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,686,539	13,420	20,735	61,488
	AvgComSales	16.4	11.9	68.0	12.6%	186.6	11.7%	5,055,097	8,846	18,124	54,323
	Triple_Lowe	-0.2	18.0	17.4	3.2%	17.7	1.1%	5,693,867	6,494	20,068	60,809
	High_R_Tint	-0.9	16.6	13.5	2.5%	8.5	0.5%	5,721,359	7,063	20,218	61,161
	High_R_Clear	18.2	17.1	79.3	14.7%	211.3	13.2%	4,986,022	6,855	17,690	53,377
	189.1	-0.1	7.8	7.4	1.4%	7.5	0.5%	5,690,084	10,443	20,450	61,200
	EC_Window	4.7	14.2	30.2	5.6%	65.1	4.1%	5,506,328	7,962	19,575	58,989
	EC_HR_Window	6.6	16.5	38.9	7.2%	87.4	5.5%	5,434,261	7,090	19,242	58,134
Chicago	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3,968,792	55,802	19,115	47,985
	AvgComSales	-3.6	3.3	-9.1	-1.8%	-34.6	-2.8%	4,107,964	54,531	19,463	49,315
	Triple_Lowe	2.1	47.4	54.6	11.0%	73.9	5.9%	3,888,525	37,591	17,020	45,149
	High_R_Tint	1.4	35.2	40.0	8.0%	53.4	4.3%	3,914,408	42,290	17,579	45,935
	High_R_Clear	-2.2	41.7	34.0	6.8%	21.9	1.8%	4,054,936	39,790	17,808	47,145
	189.1	-0.3	17.0	15.9	3.2%	15.1	1.2%	3,981,561	49,279	18,506	47,407
	EC_Window	6.1	24.3	44.9	9.0%	90.5	7.2%	3,735,831	46,489	17,390	44,509
	EC_HR_Window	6.9	47.1	70.7	14.2%	124.4	10.0%	3,703,308	37,722	16,402	43,208

Table 44 – Relative Energy Savings, low vs. normal internal loads, Shades On If High Glare, Daylighting

Climates	Windows	Relative Energy Savings per ft² of Window Area			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	0.5	4.5	6.1	10.0
	Triple_Lowe	0.9	7.4	10.6	17.8
	High_R_Tint	0.8	6.8	9.6	16.1
	High_R_Clear	0.9	7.0	10.1	17.2
	189.1	0.6	3.5	5.5	10.1
	EC_Window	0.9	6.8	9.8	16.9
	EC_HR_Window	2.2	9.2	16.8	33.7
Phoenix	AvgComSales	23.2	1.3	80.4	246.2
	Triple_Lowe	-0.1	1.4	1.1	0.7
	High_R_Tint	-0.2	1.3	0.5	-1.0
	High_R_Clear	23.3	1.3	80.7	247.3
	189.1	0.0	0.6	0.5	0.4
	EC_Window	0.7	1.2	3.6	8.9
	EC_HR_Window	1.2	1.3	5.2	13.7
Chicago	AvgComSales	0.2	2.1	2.9	4.7
	Triple_Lowe	0.5	3.7	5.5	9.7
	High_R_Tint	0.3	2.6	3.8	6.4
	High_R_Clear	0.3	5.3	6.2	8.6
	189.1	0.2	1.5	2.3	4.1
	EC_Window	0.8	-1.2	1.7	7.6
	EC_HR_Window	1.3	2.5	6.8	16.0

Table 45 – Relative Energy Savings, Different Shading Controls, No Daylighting

Climates	Shading Controls	Shades Always On vs Shades OnIfHG Relative Energy Savings per ft² of Window Area Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²	Shades Always Off vs Shades OnIfHG Relative Energy Savings per ft² of Window Area Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	3.3	-14.2	-3.0	19.2	0.0	0.4	0.3	0.3
	Triple_Lowe	1.1	-20.2	-16.5	-10.6	0.0	0.1	0.1	0.0
	High_R_Tint	0.8	-19.6	-16.9	-13.0	0.0	0.1	0.1	0.1
	High_R_Clear	3.1	-19.2	-8.7	11.5	0.0	0.2	0.1	-0.2
	189.1	0.5	-15.3	-13.7	-11.9	0.0	0.1	0.1	0.1
	EC_Window	-0.7	-24.4	-26.9	-34.4	-6.7	-0.8	-23.6	-71.4
	EC_HR_Window	-0.7	-25.0	-27.6	-35.1	-5.2	0.9	-16.8	-53.5
Phoenix	AvgComSales	5.2	-4.9	12.9	49.9	-0.2	0.5	-0.1	-1.2
	Triple_Lowe	-0.4	-8.5	-10.1	-14.0	-0.1	0.1	-0.1	-0.5
	High_R_Tint	0.0	-8.2	-8.0	-8.5	0.0	0.1	0.0	-0.3
	High_R_Clear	3.6	-7.6	4.8	30.1	-0.1	0.3	-0.2	-1.2
	189.1	-0.1	-4.5	-4.8	-5.8	0.0	0.1	0.0	-0.2
	EC_Window	-0.9	-10.3	-13.5	-21.0	-5.9	1.4	-18.8	-60.9
	EC_HR_Window	-0.7	-10.7	-13.2	-19.4	-4.4	2.0	-13.1	-44.4
Chicago	AvgComSales	2.7	0.8	10.0	29.1	0.0	0.5	0.3	0.0
	Triple_Lowe	-2.4	-19.8	-27.9	-46.7	0.0	0.0	-0.1	-0.3
	High_R_Tint	-1.3	-15.3	-19.8	-30.9	-0.1	0.1	-0.1	-0.5
	High_R_Clear	1.2	-16.3	-12.3	-5.5	-0.1	0.6	0.4	0.0
	189.1	0.2	-7.3	-6.5	-5.7	0.0	0.2	0.1	-0.1
	EC_Window	-2.9	-29.7	-39.6	-63.2	-4.5	6.8	-8.6	-40.1
	EC_HR_Window	-2.7	-30.2	-39.3	-61.2	-4.0	7.1	-6.5	-34.3

Table 46 – Relative Energy Savings, Different Shading Controls, Daylighting

Climates	Shading Controls	Shades Always On vs Shades OnIfHG Relative Energy Savings per ft² of Window Area Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²	Shades Always Off vs Shades OnIfHG Relative Energy Savings per ft² of Window Area Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	Source Energy kBtu/ft²
San Francisco	AvgComSales	3.4	-16.6	-5.2	17.3	0.0	0.5	0.4	0.4
	Triple_Lowe	0.1	-24.0	-23.7	-25.3	0.0	0.1	0.1	0.1
	High_R_Tint	0.8	-22.7	-20.1	-16.6	0.0	0.2	0.1	0.2
	High_R_Clear	3.1	-22.4	-11.9	7.9	0.0	0.3	0.3	0.2
	189.1	-0.2	-18.1	-18.9	-22.2	0.0	0.1	0.1	0.2
	EC_Window	-0.4	-24.3	-25.6	-30.4	0.0	0.0	-0.2	-0.4
	EC_HR_Window	-0.4	-24.3	-25.6	-30.4	0.0	0.0	-0.2	-0.4
Phoenix	AvgComSales	5.0	-5.4	11.7	47.1	-0.1	0.5	0.2	-0.5
	Triple_Lowe	-0.6	-9.1	-11.0	-16.0	0.0	0.1	0.0	-0.1
	High_R_Tint	-0.1	-8.6	-9.0	-10.7	0.0	0.1	0.0	-0.2
	High_R_Clear	3.4	-8.2	3.3	26.7	-0.1	0.3	-0.1	-0.9
	189.1	-0.2	-4.7	-5.3	-7.2	0.0	0.1	0.1	0.0
	EC_Window	-1.1	-9.3	-13.1	-21.7	-0.1	-0.2	-0.4	-0.8
	EC_HR_Window	-1.1	-9.3	-13.1	-21.7	-0.1	-0.2	-0.4	-0.8
Chicago	AvgComSales	2.9	0.0	9.8	30.6	0.0	0.5	0.5	0.3
	Triple_Lowe	-2.7	-22.3	-31.3	-52.4	0.0	0.2	0.1	-0.2
	High_R_Tint	-1.9	-17.8	-24.4	-39.7	0.0	0.3	0.3	0.2
	High_R_Clear	1.4	-17.7	-13.1	-5.0	0.0	0.9	0.8	0.5
	189.1	0.0	-9.1	-9.0	-9.8	0.0	0.4	0.4	0.4
	EC_Window	-2.2	-24.9	-32.5	-50.7	-0.1	-0.3	-0.6	-1.3
	EC_HR_Window	-2.2	-24.9	-32.5	-50.7	-0.1	-0.3	-0.6	-1.3

Recommendations on Future Work

Future studies can further assess:

- The energy impacts of window technologies for other building types such as medium-size office buildings and large hotels. The medium-size office buildings are more representative than the large office buildings in the US according to CBECS. Large hotels tend to have higher window-wall-ratio than other building types so energy savings can be more attractive.
- The impact of baseline shading controls. For example assuming no shades or shades always on in the base cases instead of the shades on if high glare used in this study.
- The energy impacts of windows in other climates like Washington D.C.
- The energy savings potential of window technologies for ZEBs that have less internal loads due to efficient lighting systems and EnergyStar appliances, better insulation of building envelope, and high efficient HVAC systems.
- The energy impact of other window technologies, for example, the thermochromic windows whose solar properties depend on the thermochromic layer temperature.
- National energy impact estimate
  The calculated energy savings by different types of window technologies are based on specific building types in certain climates and could be normalized on the basis of per unit of building floor area or window area. Data of national profile of commercial building stocks or commercial window sales is needed to estimate the national energy impact. Two different approaches may be used – one based on the total building floor area by climates, the other based on the total windows sales by climates. The two approaches may come up with different results. It is worth looking into which approach provides more reliable estimate.

References

Energy Information Administration, Annual Energy Review 2006*, Washington, DC, June 2007.*

Energy Information Administration, Commercial Building Energy Consumption Survey 2003, Washington, DC, December 2006.

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, 2007 Buildings Energy Data Book, September 2007.

Energy Information Administration, Annual Energy Outlook 2007, Washington, DC, 2007.

E.S. Lee, et al. The energy savings potential of electrochromic windows in the US commercial buildings sector, Lawrence Berkeley National Laboratory, LBNL-54966, 2004.

J. Apte, D. Arasteh. Window-related energy consumption in the US residential and commercial building stock, Lawrence Berkeley National Laboratory, LBNL-60146, 2006.

D. Arasteh, et al. Zero energy windows, Lawrence Berkeley National Laboratory, LBNL-60049, 2006

D. Arasteh, et al. Evaluating fenestration products for zero-energy buildings: issues for discussion, Lawrence Berkeley National Laboratory, LBNL-61249, 2006.

P. Haves, et al. Assessment of building control systems: expected performance benefits of integrated control, Lawrence Berkeley National Laboratory, 2007.

M. LaFrance. Windows multi-year plan 2008-2012, US Department of Energy, 2007.

J. Huang, M. Yazdanian. Analysis of window energy savings in commercial buildings in the Pacific Northwest, Lawrence Berkeley National Laboratory, LBNL-60379, 2007.

B. Griffith, et al. Assessment of the technical potential for achieving net zero-energy buildings in the commercial sector, National Renewable Energy Laboratory, NREL/TP-550-41957, 2007.

E.S. Lee, et al. Energy performance analysis of electrochromic windows in New York commercial office buildings, Lawrence Berkeley National Laboratory, LBNL-50096, 2002.

Appendix - Simulation Results and Energy Savings of the Large Office Building

Table 47 – Whole Building Energy Use and Savings (Shades On If High Glare, No Daylighting)

Values for the base case windows are the absolute energy use of the base case.

		Energy Savings per ft² of Building Floor Area						Whole Building Energy Use			
Climates	Windows	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	***11.16***	***3.52***	***41.6***	***n.a.***	***121.7***	***n.a.***	5,138,180	16,194	19,143	56,003
	AvgComSales	-0.53	1.56	-0.23	-0.5%	-3.84	-3.2%	5,380,097	8,993	19,247	57,770
	Triple_Lowe	-0.17	2.39	1.80	4.3%	0.79	0.6%	5,217,767	5,181	18,313	55,640
	High_R_Tint	-0.20	2.25	1.58	3.8%	0.37	0.3%	5,229,045	5,844	18,417	55,831
	High_R_Clear	-0.56	2.24	0.33	0.8%	-3.48	-2.9%	5,396,314	5,898	18,993	57,603
	189.1	0.00	1.67	1.68	4.0%	1.84	1.5%	5,137,733	8,489	18,371	55,156
	EC_Window	0.21	2.21	2.94	7.1%	4.67	3.8%	5,039,500	6,042	17,791	53,852
	EC_HR_Window	0.14	2.35	2.81	6.8%	4.00	3.3%	5,075,705	5,383	17,848	54,163
Miami	base case	***14.44***	***0.55***	***49.8***	***n.a.***	***153.0***	***n.a.***	6,643,856	2,512	22,909	70,401
	AvgComSales	-0.80	0.07	-2.66	-5.3%	-8.37	-5.5%	7,012,025	2,206	24,134	74,254
	Triple_Lowe	-0.32	0.10	-0.98	-2.0%	-3.23	-2.1%	6,789,350	2,062	23,360	71,888
	High_R_Tint	-0.36	0.09	-1.12	-2.2%	-3.65	-2.4%	6,807,347	2,082	23,424	72,080
	High_R_Clear	-0.78	0.09	-2.58	-5.2%	-8.18	-5.3%	7,004,836	2,084	24,098	74,165
	189.1	-0.01	0.00	-0.03	-0.1%	-0.09	-0.1%	6,647,855	2,497	22,921	70,442
	EC_Window	-0.04	0.09	-0.04	-0.1%	-0.30	-0.2%	6,661,250	2,093	22,927	70,539
	EC_HR_Window	0.00	0.10	0.08	0.2%	0.06	0.0%	6,645,797	2,061	22,871	70,372
Phoenix	base case	***14.06***	***2.40***	***50.3***	***n.a.***	***151.0***	***n.a.***	6,469,528	11,024	23,166	69,491
	AvgComSales	-0.67	0.83	-1.45	-2.9%	-6.14	-4.1%	6,776,475	7,226	23,833	72,316
	Triple_Lowe	-0.03	1.29	1.19	2.4%	1.10	0.7%	6,483,081	5,096	22,619	68,986
	High_R_Tint	-0.09	1.19	0.88	1.8%	0.35	0.2%	6,511,053	5,540	22,759	69,330
	High_R_Clear	-0.53	1.22	-0.57	-1.1%	-4.22	-2.8%	6,711,647	5,388	23,428	71,431
	189.1	-0.02	0.56	0.51	1.0%	0.44	0.3%	6,477,264	8,426	22,933	69,288
	EC_Window	0.25	1.07	1.93	3.8%	3.80	2.5%	6,354,742	6,084	22,280	67,740
	EC_HR_Window	0.37	1.25	2.51	5.0%	5.28	3.5%	6,298,805	5,281	22,009	67,061
Chicago	base case	***12.18***	***9.41***	***51.0***	***n.a.***	***138.9***	***n.a.***	5,607,367	43,308	23,454	63,916
	AvgComSales	-0.33	0.04	-1.07	-2.1%	-3.39	-2.4%	5,757,028	43,133	23,947	65,476
	Triple_Lowe	0.20	3.35	4.02	7.9%	5.74	4.1%	5,516,442	27,907	21,604	61,274
	High_R_Tint	0.12	2.46	2.85	5.6%	3.91	2.8%	5,553,708	32,005	22,141	62,115
	High_R_Clear	-0.22	2.82	2.08	4.1%	0.78	0.6%	5,707,603	30,315	22,497	63,555
	189.1	-0.03	1.13	1.03	2.0%	0.92	0.7%	5,621,317	38,089	22,980	63,493
	EC_Window	0.45	2.14	3.66	7.2%	7.05	5.1%	5,401,647	33,468	21,769	60,670
	EC_HR_Window	0.48	3.64	5.28	10.4%	9.05	6.5%	5,386,083	26,555	21,024	59,751
Duluth	base case	***11.68***	***14.88***	***54.7***	***n.a.***	***139.6***	***n.a.***	5,377,647	68,460	25,186	64,238
	AvgComSales	-0.11	-0.32	-0.71	-1.3%	-1.55	-1.1%	5,429,789	69,943	25,512	64,950
	Triple_Lowe	0.43	5.06	6.53	11.9%	10.09	7.2%	5,178,956	45,164	22,179	59,596
	High_R_Tint	0.39	3.66	4.98	9.1%	8.08	5.8%	5,199,939	51,594	22,893	60,520
	High_R_Clear	-0.02	4.29	4.22	7.7%	4.47	3.2%	5,387,422	48,695	23,243	62,182
	189.1	-0.08	3.46	3.19	5.8%	2.94	2.1%	5,414,095	52,529	23,717	62,883
	EC_Window	0.79	2.84	5.52	10.1%	11.40	8.2%	5,015,589	55,402	22,645	58,990
	EC_HR_Window	0.81	5.53	8.28	15.1%	14.56	10.4%	5,006,369	43,004	21,374	57,539

Table 48 – Whole Building Energy Use and Savings (Shades On If High Glare, With Daylighting)

Values for the base case windows are the absolute energy use of the base case.

		Energy Savings per ft² of Building Floor Area						Whole Building Energy Use			
Climates	Windows	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	***10.45***	***4.06***	***39.7***	***n.a.***	***114.7***	***n.a.***	4,807,681	18,697	18,266	52,787
	AvgComSales	-0.49	1.83	0.18	0.4%	-3.14	-2.7%	5,031,731	10,253	18,185	54,230
	Triple_Lowe	-0.19	2.83	2.18	5.5%	1.07	0.9%	4,895,753	5,672	17,264	52,295
	High_R_Tint	-0.20	2.64	1.96	4.9%	0.76	0.7%	4,900,239	6,537	17,365	52,437
	High_R_Clear	-0.53	2.63	0.84	2.1%	-2.67	-2.3%	5,049,525	6,578	17,879	54,017
	189.1	-0.03	1.95	1.86	4.7%	1.85	1.6%	4,819,703	9,745	17,412	51,937
	EC_Window	0.19	2.39	3.03	7.6%	4.59	4.0%	4,721,189	7,700	16,871	50,674
	EC_HR_Window	0.10	2.56	2.89	7.3%	3.82	3.3%	4,762,628	6,936	16,936	51,028
Miami	base case	***13.70***	***0.57***	***47.3***	***n.a.***	***145.2***	***n.a.***	6,304,295	2,617	21,762	66,828
	AvgComSales	-0.72	0.08	-2.39	-5.0%	-7.54	-5.2%	6,636,739	2,260	22,860	70,298
	Triple_Lowe	-0.32	0.12	-0.99	-2.1%	-3.29	-2.3%	6,453,331	2,088	22,217	68,344
	High_R_Tint	-0.32	0.11	-1.00	-2.1%	-3.30	-2.3%	6,453,467	2,113	22,220	68,348
	High_R_Clear	-0.71	0.11	-2.30	-4.9%	-7.33	-5.0%	6,629,053	2,111	22,819	70,201
	189.1	-0.01	0.00	-0.02	0.0%	-0.07	0.0%	6,307,267	2,600	21,770	66,858
	EC_Window	0.02	0.10	0.16	0.3%	0.28	0.2%	6,296,850	2,141	21,689	66,698
	EC_HR_Window	0.04	0.11	0.26	0.6%	0.58	0.4%	6,284,306	2,098	21,642	66,561
Phoenix	base case	***13.36***	***2.62***	***48.2***	***n.a.***	***143.9***	***n.a.***	6,147,642	12,048	22,171	66,205
	AvgComSales	-0.56	0.89	-1.03	-2.1%	-4.96	-3.5%	6,406,408	7,967	22,645	68,490
	Triple_Lowe	-0.01	1.39	1.36	2.8%	1.41	1.0%	6,152,014	5,663	21,547	65,554
	High_R_Tint	-0.06	1.27	1.08	2.2%	0.79	0.6%	6,173,797	6,183	21,673	65,840
	High_R_Clear	-0.42	1.32	-0.12	-0.2%	-3.00	-2.1%	6,341,453	5,979	22,225	67,588
	189.1	-0.01	0.59	0.58	1.2%	0.59	0.4%	6,150,353	9,310	21,906	65,934
	EC_Window	0.33	1.09	2.22	4.6%	4.69	3.3%	5,995,092	7,044	21,150	64,048
	EC_HR_Window	0.45	1.27	2.81	5.8%	6.14	4.3%	5,940,233	6,207	20,879	63,378
Chicago	base case	***11.39***	***10.07***	***48.9***	***n.a.***	***131.2***	***n.a.***	5,242,081	46,343	22,512	60,392
	AvgComSales	-0.32	0.10	-1.00	-2.0%	-3.28	-2.5%	5,390,047	45,878	22,970	61,903
	Triple_Lowe	0.13	3.64	4.09	8.4%	5.36	4.1%	5,182,155	29,568	20,630	57,927
	High_R_Tint	0.09	2.72	3.02	6.2%	3.92	3.0%	5,200,411	33,847	21,120	58,587
	High_R_Clear	-0.21	3.04	2.32	4.7%	1.11	0.8%	5,338,503	32,369	21,443	59,883
	189.1	-0.05	1.29	1.13	2.3%	0.91	0.7%	5,263,966	40,396	21,992	59,973
	EC_Window	0.44	2.12	3.61	7.4%	6.92	5.3%	5,041,397	36,581	20,851	57,207
	EC_HR_Window	0.47	3.72	5.33	10.9%	9.05	6.9%	5,024,705	29,240	20,060	56,229
Duluth	base case	***10.90***	***15.85***	***53.0***	***n.a.***	***132.3***	***n.a.***	5,015,975	72,958	24,402	60,911
	AvgComSales	-0.10	-0.31	-0.65	-1.2%	-1.39	-1.0%	5,061,731	74,377	24,700	61,549
	Triple_Lowe	0.38	5.39	6.68	12.6%	9.86	7.5%	4,842,553	48,140	21,329	56,371
	High_R_Tint	0.33	3.86	4.99	9.4%	7.73	5.8%	4,862,470	55,207	22,104	57,353
	High_R_Clear	-0.01	4.52	4.49	8.5%	4.85	3.7%	5,019,836	52,140	22,334	58,679
	189.1	-0.07	3.62	3.39	6.4%	3.25	2.5%	5,046,408	56,317	22,842	59,415
	EC_Window	0.74	2.49	5.03	9.5%	10.57	8.0%	4,673,706	61,492	22,088	56,047
	EC_HR_Window	0.78	5.49	8.16	15.4%	14.26	10.8%	4,655,564	47,692	20,646	54,348

Table 49 – Whole Building Energy Use and Savings (Shades Always Off, No Daylighting)

Values for the base case windows are the absolute energy use of the base case.

Climates	Windows	Energy Savings per ft² of Building Floor Area						Whole Building Energy Use			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	***11.16***	***3.52***	***41.6***	***n.a.***	***121.7***	***n.a.***	5,138,192	16,178	19,141	56,001
	AvgComSales	-0.53	1.60	-0.20	-0.5%	-3.82	-3.1%	5,380,736	8,817	19,232	57,757
	Triple_Lowe	-0.17	2.40	1.81	4.3%	0.79	0.6%	5,217,900	5,140	18,309	55,637
	High_R_Tint	-0.20	2.26	1.59	3.8%	0.38	0.3%	5,228,972	5,785	18,411	55,824
	High_R_Clear	-0.56	2.26	0.33	0.8%	-3.49	-2.9%	5,397,861	5,797	18,988	57,608
	189.1	0.00	1.68	1.69	4.1%	1.85	1.5%	5,137,639	8,438	18,365	55,150
	EC_Window	-0.34	2.14	0.97	2.3%	-1.28	-1.1%	5,296,202	6,316	18,694	56,592
	EC_HR_Window	-0.29	2.42	1.42	3.4%	-0.47	-0.4%	5,273,856	5,033	18,489	56,216
Miami	base case	***14.43***	***0.54***	***49.8***	***n.a.***	***152.9***	***n.a.***	6,641,616	2,502	22,901	70,376
	AvgComSales	-0.81	0.07	-2.71	-5.4%	-8.52	-5.6%	7,016,374	2,194	24,148	74,298
	Triple_Lowe	-0.33	0.10	-1.01	-2.0%	-3.34	-2.2%	6,791,716	2,060	23,368	71,912
	High_R_Tint	-0.37	0.09	-1.15	-2.3%	-3.76	-2.5%	6,809,772	2,078	23,432	72,105
	High_R_Clear	-0.80	0.09	-2.64	-5.3%	-8.36	-5.5%	7,010,472	2,079	24,116	74,224
	189.1	-0.01	0.00	-0.02	0.0%	-0.08	-0.1%	6,645,172	2,488	22,911	70,412
	EC_Window	-0.52	0.09	-1.69	-3.4%	-5.43	-3.5%	6,882,388	2,089	23,681	72,873
	EC_HR_Window	-0.40	0.10	-1.26	-2.5%	-4.10	-2.7%	6,824,944	2,045	23,480	72,262
Phoenix	base case	***14.06***	***2.39***	***50.3***	***n.a.***	***151.0***	***n.a.***	6,471,664	10,979	23,169	69,508
	AvgComSales	-0.68	0.86	-1.46	-2.9%	-6.24	-4.1%	6,784,736	7,006	23,839	72,379
	Triple_Lowe	-0.03	1.29	1.18	2.3%	1.05	0.7%	6,487,328	5,022	22,626	69,023
	High_R_Tint	-0.09	1.20	0.88	1.8%	0.32	0.2%	6,514,728	5,448	22,763	69,359
	High_R_Clear	-0.54	1.25	-0.59	-1.2%	-4.32	-2.9%	6,719,194	5,242	23,439	71,494
	189.1	-0.02	0.57	0.51	1.0%	0.42	0.3%	6,480,414	8,343	22,935	69,313
	EC_Window	-0.24	1.19	0.36	0.7%	-1.28	-0.8%	6,583,878	5,511	23,005	70,096
	EC_HR_Window	0.00	1.41	1.43	2.8%	1.58	1.0%	6,470,006	4,478	22,513	68,781
Chicago	base case	***12.18***	***9.37***	***50.9***	***n.a.***	***138.8***	***n.a.***	5,606,753	43,110	23,432	63,888
	AvgComSales	-0.33	0.08	-1.05	-2.1%	-3.39	-2.4%	5,758,328	42,752	23,913	65,448
	Triple_Lowe	0.19	3.35	4.01	7.9%	5.71	4.1%	5,517,116	27,694	21,585	61,258
	High_R_Tint	0.11	2.46	2.84	5.6%	3.87	2.8%	5,555,036	31,784	22,123	62,105
	High_R_Clear	-0.22	2.88	2.11	4.2%	0.78	0.6%	5,709,658	29,873	22,459	63,528
	189.1	-0.03	1.15	1.04	2.0%	0.91	0.7%	5,621,764	37,831	22,955	63,470
	EC_Window	0.07	2.70	2.95	5.8%	3.71	2.7%	5,573,586	30,676	22,076	62,180
	EC_HR_Window	0.15	4.23	4.74	9.3%	6.19	4.5%	5,538,574	23,636	21,252	61,041
Duluth	base case	***11.69***	***14.77***	***54.6***	***n.a.***	***139.5***	***n.a.***	5,379,661	67,977	25,144	64,206
	AvgComSales	-0.11	-0.32	-0.70	-1.3%	-1.53	-1.1%	5,431,130	69,442	25,466	64,909
	Triple_Lowe	0.43	5.03	6.51	11.9%	10.07	7.2%	5,179,850	44,832	22,149	59,570
	High_R_Tint	0.39	3.64	4.96	9.1%	8.08	5.8%	5,200,375	51,239	22,859	60,486
	High_R_Clear	-0.02	4.34	4.26	7.8%	4.49	3.2%	5,390,650	47,988	23,183	62,139
	189.1	-0.08	3.51	3.23	5.9%	2.97	2.1%	5,417,442	51,801	23,656	62,838
	EC_Window	0.29	3.92	4.91	9.0%	7.32	5.3%	5,247,111	49,916	22,886	60,835
	EC_HR_Window	0.44	6.58	8.07	14.8%	11.79	8.5%	5,179,064	37,674	21,430	58,780

Table 50 – Whole Building Energy Use and Savings (Shades Always Off, With Daylighting)

Values for the base case windows are the absolute energy use of the base case.

		Energy Savings per ft² of Building Floor Area						Whole Building Energy Use			
Climates	Windows	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	***10.44***	***4.06***	***39.7***	***n.a.***	***114.7***	***n.a.***	4,806,252	18,693	18,260	52,772
	AvgComSales	-0.49	1.88	0.21	0.5%	-3.10	-2.7%	5,031,047	10,051	18,163	54,201
	Triple_Lowe	-0.19	2.84	2.18	5.5%	1.08	0.9%	4,894,425	5,629	17,255	52,276
	High_R_Tint	-0.20	2.66	1.97	5.0%	0.77	0.7%	4,899,008	6,471	17,355	52,416
	High_R_Clear	-0.53	2.66	0.86	2.2%	-2.66	-2.3%	5,048,770	6,452	17,863	53,995
	189.1	-0.03	1.95	1.87	4.7%	1.86	1.6%	4,818,044	9,700	17,401	51,914
	EC_Window	0.18	2.39	3.02	7.6%	4.56	4.0%	4,721,188	7,700	16,871	50,674
	EC_HR_Window	0.09	2.55	2.88	7.3%	3.79	3.3%	4,762,628	6,936	16,936	51,028
Miami	base case	***13.69***	***0.56***	***47.2***	***n.a.***	***145.1***	***n.a.***	6,298,733	2,600	21,741	66,768
	AvgComSales	-0.74	0.08	-2.44	-5.2%	-7.69	-5.3%	6,637,797	2,242	22,862	70,308
	Triple_Lowe	-0.33	0.11	-1.02	-2.2%	-3.39	-2.3%	6,451,902	2,084	22,212	68,328
	High_R_Tint	-0.33	0.11	-1.03	-2.2%	-3.40	-2.3%	6,451,978	2,107	22,214	68,332
	High_R_Clear	-0.72	0.11	-2.36	-5.0%	-7.53	-5.2%	6,632,056	2,104	22,828	70,232
	189.1	-0.01	0.00	-0.02	0.0%	-0.06	0.0%	6,301,689	2,583	21,749	66,797
	EC_Window	0.00	0.10	0.11	0.2%	0.15	0.1%	6,296,850	2,141	21,689	66,698
	EC_HR_Window	0.03	0.11	0.22	0.5%	0.45	0.3%	6,284,306	2,098	21,642	66,561
Phoenix	base case	***13.35***	***2.60***	***48.1***	***n.a.***	***143.8***	***n.a.***	6,145,711	11,959	22,155	66,175
	AvgComSales	-0.57	0.93	-1.02	-2.1%	-5.01	-3.5%	6,408,586	7,672	22,623	68,481
	Triple_Lowe	-0.01	1.39	1.36	2.8%	1.41	1.0%	6,150,588	5,543	21,530	65,526
	High_R_Tint	-0.06	1.29	1.08	2.3%	0.78	0.5%	6,173,083	6,039	21,656	65,817
	High_R_Clear	-0.43	1.34	-0.12	-0.3%	-3.08	-2.1%	6,343,933	5,770	22,212	67,591
	189.1	-0.01	0.60	0.58	1.2%	0.59	0.4%	6,148,730	9,181	21,888	65,903
	EC_Window	0.33	1.07	2.18	4.5%	4.62	3.2%	5,995,092	7,044	21,150	64,048
	EC_HR_Window	0.45	1.25	2.77	5.8%	6.08	4.2%	5,940,233	6,207	20,879	63,378
Chicago	base case	***11.38***	***10.04***	***48.9***	***n.a.***	***131.1***	***n.a.***	5,238,606	46,219	22,488	60,341
	AvgComSales	-0.32	0.15	-0.96	-2.0%	-3.26	-2.5%	5,387,725	45,542	22,928	61,841
	Triple_Lowe	0.13	3.66	4.10	8.4%	5.34	4.1%	5,180,025	29,369	20,603	57,883
	High_R_Tint	0.09	2.74	3.05	6.2%	3.94	3.0%	5,197,088	33,620	21,086	58,527
	High_R_Clear	-0.21	3.11	2.39	4.9%	1.15	0.9%	5,336,361	31,913	21,390	59,811
	189.1	-0.05	1.32	1.16	2.4%	0.95	0.7%	5,260,208	40,132	21,953	59,905
	EC_Window	0.43	2.09	3.56	7.3%	6.81	5.2%	5,041,397	36,581	20,851	57,207
	EC_HR_Window	0.46	3.69	5.28	10.8%	8.93	6.8%	5,024,706	29,240	20,060	56,229
Duluth	base case	***10.89***	***15.76***	***52.9***	***n.a.***	***132.2***	***n.a.***	5,014,000	72,516	24,351	60,842
	AvgComSales	-0.10	-0.30	-0.65	-1.2%	-1.39	-1.1%	5,060,078	73,910	24,648	61,481
	Triple_Lowe	0.38	5.36	6.65	12.6%	9.84	7.4%	4,839,722	47,863	21,292	56,311
	High_R_Tint	0.34	3.82	4.97	9.4%	7.73	5.8%	4,858,994	54,934	22,064	57,286
	High_R_Clear	-0.01	4.57	4.54	8.6%	4.91	3.7%	5,017,297	51,491	22,260	58,581
	189.1	-0.07	3.67	3.45	6.5%	3.31	2.5%	5,044,380	55,616	22,765	59,317
	EC_Window	0.74	2.40	4.92	9.3%	10.42	7.9%	4,673,706	61,492	22,088	56,047
	EC_HR_Window	0.78	5.39	8.05	15.2%	14.11	10.7%	4,655,564	47,692	20,646	54,348

Table 51 – Whole Building Energy Use and Savings (Shades Always On, No Daylighting)

Values for the base case windows are the absolute energy use of the base case.

Climates	Windows	Energy Savings per ft² of Building Floor Area						Whole Building Energy Use			
		Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	***11.05***	***1.79***	***39.5***	***n.a.***	***118.5***	***n.a.***	5,083,739	8,246	18,162	54,560
	AvgComSales	-0.25	0.38	-0.48	-1.2%	-2.24	-1.9%	5,199,586	6,484	18,381	55,590
	Triple_Lowe	-0.08	0.71	0.43	1.1%	-0.10	-0.1%	5,121,736	4,983	17,965	54,605
	High_R_Tint	-0.13	0.62	0.17	0.4%	-0.71	-0.6%	5,143,948	5,412	18,084	54,886
	High_R_Clear	-0.30	0.63	-0.40	-1.0%	-2.51	-2.1%	5,223,536	5,330	18,347	55,717
	189.1	0.04	0.40	0.53	1.3%	0.85	0.7%	5,065,944	6,403	17,917	54,171
	EC_Window	0.15	0.17	0.69	1.8%	1.80	1.5%	5,013,130	7,469	17,844	53,730
	EC_HR_Window	0.07	0.26	0.51	1.3%	1.07	0.9%	5,049,514	7,051	17,926	54,068
Miami	base case	***14.43***	***0.48***	***49.7***	***n.a.***	***152.9***	***n.a.***	6,643,044	2,193	22,875	70,358
	AvgComSales	-0.27	0.02	-0.90	-1.8%	-2.84	-1.9%	6,767,992	2,096	23,291	71,666
	Triple_Lowe	-0.21	0.03	-0.67	-1.4%	-2.13	-1.4%	6,737,422	2,065	23,184	71,340
	High_R_Tint	-0.20	0.03	-0.65	-1.3%	-2.07	-1.4%	6,734,489	2,076	23,175	71,310
	High_R_Clear	-0.34	0.03	-1.11	-2.2%	-3.51	-2.3%	6,797,392	2,062	23,388	71,973
	189.1	0.00	0.00	-0.01	0.0%	-0.03	0.0%	6,644,508	2,190	22,879	70,373
	EC_Window	0.07	0.01	0.27	0.5%	0.80	0.5%	6,608,714	2,132	22,751	69,989
	EC_HR_Window	0.12	0.02	0.41	0.8%	1.24	0.8%	6,590,074	2,099	22,685	69,788
Phoenix	base case	***13.86***	***1.69***	***49.0***	***n.a.***	***148.2***	***n.a.***	6,380,644	7,793	22,540	68,200
	AvgComSales	-0.23	0.41	-0.37	-0.8%	-1.97	-1.3%	6,486,397	5,888	22,710	69,108
	Triple_Lowe	-0.07	0.58	0.35	0.7%	-0.07	0.0%	6,411,358	5,143	22,379	68,234
	High_R_Tint	-0.09	0.51	0.21	0.4%	-0.36	-0.2%	6,420,620	5,452	22,442	68,366
	High_R_Clear	-0.22	0.59	-0.17	-0.3%	-1.71	-1.2%	6,483,172	5,080	22,618	68,985
	189.1	-0.02	0.19	0.11	0.2%	-0.04	0.0%	6,391,642	6,922	22,490	68,220
	EC_Window	0.17	0.22	0.80	1.6%	2.05	1.4%	6,301,436	6,803	22,171	67,255
	EC_HR_Window	0.31	0.36	1.41	2.9%	3.66	2.5%	6,238,128	6,141	21,889	66,515
Chicago	base case	***11.86***	***7.56***	***48.0***	***n.a.***	***133.5***	***n.a.***	5,459,600	34,812	22,101	61,428
	AvgComSales	-0.10	0.11	-0.24	-0.5%	-0.96	-0.7%	5,506,494	34,319	22,211	61,869
	Triple_Lowe	0.00	1.69	1.69	3.5%	1.84	1.4%	5,459,880	27,018	21,322	60,580
	High_R_Tint	0.00	1.18	1.20	2.5%	1.34	1.0%	5,457,386	29,387	21,550	60,812
	High_R_Clear	-0.12	1.47	1.06	2.2%	0.33	0.2%	5,515,236	28,062	21,615	61,278
	189.1	-0.01	0.53	0.49	1.0%	0.44	0.3%	5,465,447	32,382	21,877	61,225
	EC_Window	0.20	-0.34	0.36	0.7%	1.78	1.3%	5,365,872	36,372	21,937	60,609
	EC_HR_Window	0.26	1.12	2.00	4.2%	3.94	3.0%	5,340,806	29,667	21,181	59,613
Duluth	base case	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	5,140,158	55,431	23,073	60,308
	AvgComSales	-0.05	-0.16	-0.33	-0.7%	-0.69	-0.5%	5,162,394	56,185	23,224	60,625
	Triple_Lowe	0.12	2.60	3.02	6.0%	4.14	3.2%	5,083,372	43,467	21,683	58,402
	High_R_Tint	0.12	1.70	2.12	4.2%	3.13	2.4%	5,084,722	47,585	22,099	58,866
	High_R_Clear	-0.07	2.16	1.94	3.9%	1.67	1.3%	5,170,366	45,474	22,180	59,540
	189.1	-0.08	1.67	1.41	2.8%	1.01	0.8%	5,175,516	47,736	22,424	59,841
	EC_Window	0.33	-1.01	0.12	0.2%	2.39	1.8%	4,987,916	60,070	23,018	59,208
	EC_HR_Window	0.38	1.68	2.97	5.9%	5.82	4.4%	4,966,374	47,700	21,707	57,630

Table 52 – Whole Building Energy Use and Savings (Shades Always On, With Daylighting)

Values for the base case windows are the absolute energy use of the base case.

		Energy Savings per ft² of Building Floor Area						Whole Building Energy Use			
Climates	Windows	Electricity kWh/ft²	Gas kBtu//ft²	Site Energy kBtu/ft²	% Site Energy	Source Energy kBtu/ft²	% Source Energy	Electricity kWh	Gas Therm	Site Energy MBtu	Source Energy MBtu
San Francisco	base case	***10.42***	***2.03***	***37.6***	***n.a.***	***112.2***	***n.a.***	4,793,808	9,353	17,284	51,621
	AvgComSales	-0.21	0.45	-0.26	-0.7%	-1.69	-1.5%	4,889,044	7,284	17,402	52,400
	Triple_Lowe	-0.18	0.83	0.20	0.5%	-1.04	-0.9%	4,878,680	5,526	17,191	52,099
	High_R_Tint	-0.14	0.75	0.28	0.8%	-0.62	-0.6%	4,856,694	5,897	17,153	51,907
	High_R_Clear	-0.27	0.77	-0.15	-0.4%	-2.01	-1.8%	4,918,114	5,822	17,355	52,547
	189.1	-0.05	0.43	0.28	0.7%	-0.01	0.0%	4,814,824	7,352	17,156	51,624
	EC_Window	0.16	0.36	0.90	2.4%	2.06	1.8%	4,721,188	7,700	16,871	50,674
	EC_HR_Window	0.07	0.53	0.76	2.0%	1.29	1.1%	4,762,628	6,936	16,936	51,028
Miami	base case	***13.82***	***0.49***	***47.6***	***n.a.***	***146.4***	***n.a.***	6,358,261	2,235	21,908	67,356
	AvgComSales	-0.18	0.02	-0.59	-1.2%	-1.86	-1.3%	6,440,644	2,126	22,178	68,214
	Triple_Lowe	-0.19	0.03	-0.62	-1.3%	-1.99	-1.4%	6,446,602	2,082	22,194	68,272
	High_R_Tint	-0.17	0.03	-0.55	-1.2%	-1.76	-1.2%	6,436,594	2,096	22,161	68,168
	High_R_Clear	-0.25	0.03	-0.83	-1.7%	-2.62	-1.8%	6,474,288	2,082	22,288	68,564
	189.1	0.00	0.00	-0.01	0.0%	-0.04	0.0%	6,360,000	2,232	21,913	67,374
	EC_Window	0.13	0.02	0.48	1.0%	1.43	1.0%	6,296,850	2,141	21,689	66,698
	EC_HR_Window	0.16	0.03	0.58	1.2%	1.73	1.2%	6,284,306	2,098	21,642	66,561
Phoenix	base case	***13.27***	***1.84***	***47.1***	***n.a.***	***142.0***	***n.a.***	6,105,625	8,475	21,670	65,371
	AvgComSales	-0.14	0.44	-0.05	-0.1%	-1.04	-0.7%	6,171,566	6,469	21,694	65,848
	Triple_Lowe	-0.06	0.63	0.43	0.9%	0.08	0.1%	6,132,306	5,568	21,470	65,335
	High_R_Tint	-0.07	0.55	0.33	0.7%	-0.10	-0.1%	6,136,222	5,925	21,519	65,416
	High_R_Clear	-0.14	0.63	0.16	0.3%	-0.78	-0.5%	6,169,880	5,553	21,597	65,730
	189.1	-0.02	0.21	0.13	0.3%	-0.01	0.0%	6,115,816	7,529	21,610	65,375
	EC_Window	0.24	0.31	1.13	2.4%	2.87	2.0%	5,995,092	7,044	21,150	64,048
	EC_HR_Window	0.36	0.49	1.72	3.7%	4.33	3.0%	5,940,233	6,207	20,879	63,378
Chicago	base case	***11.20***	***7.99***	***46.2***	***n.a.***	***127.0***	***n.a.***	5,156,880	36,774	21,264	58,447
	AvgComSales	-0.08	0.10	-0.17	-0.4%	-0.73	-0.6%	5,193,420	36,320	21,344	58,783
	Triple_Lowe	-0.09	1.79	1.48	3.2%	0.99	0.8%	5,198,911	28,541	20,584	57,992
	High_R_Tint	-0.07	1.23	0.99	2.1%	0.61	0.5%	5,189,030	31,102	20,807	58,167
	High_R_Clear	-0.10	1.56	1.23	2.7%	0.69	0.5%	5,200,952	29,611	20,698	58,130
	189.1	-0.05	0.53	0.38	0.8%	0.10	0.1%	5,178,094	34,314	21,091	58,403
	EC_Window	0.25	0.04	0.90	1.9%	2.69	2.1%	5,041,397	36,581	20,851	57,207
	EC_HR_Window	0.29	1.64	2.62	5.7%	4.82	3.8%	5,024,706	29,240	20,060	56,229
Duluth	base case	***10.52***	***12.84***	***48.7***	***n.a.***	***125.1***	***n.a.***	4,841,700	59,085	22,421	57,557
	AvgComSales	-0.01	-0.18	-0.23	-0.5%	-0.35	-0.3%	4,848,286	59,904	22,525	57,716
	Triple_Lowe	0.03	2.82	2.93	6.0%	3.40	2.7%	4,827,900	46,089	21,074	55,992
	High_R_Tint	0.06	1.85	2.04	4.2%	2.61	2.1%	4,815,861	50,578	21,482	56,355
	High_R_Clear	-0.01	2.33	2.29	4.7%	2.40	1.9%	4,848,106	48,352	21,369	56,452
	189.1	-0.04	1.78	1.66	3.4%	1.57	1.3%	4,857,958	50,912	21,659	56,836
	EC_Window	0.37	-0.52	0.72	1.5%	3.28	2.6%	4,673,706	61,492	22,088	56,047
	EC_HR_Window	0.40	2.48	3.86	7.9%	6.97	5.6%	4,655,564	47,692	20,646	54,348

Table 53 – Electricity Savings, San Francisco, No Daylighting

San Francisco - Shade OnIfHG - No Daylighting								
Window Area=	38388							
Run Description	**Cooling**	**Fans**	**Pumps**	**Cooling Tower**	**Total**	**Savings kWh**	**Savings kWh/ft²**	**% Savings**
base case	627,514	989,314	271,431	141,539	2,029,798	n.a.	n.a.	n.a.
AvgComSales	710,458	1,102,030	301,483	157,742	2,271,713	(241,915)	-6.30	-11.9%
Triple_Lowe	659,306	1,024,017	279,758	146,306	2,109,387	(79,589)	-2.07	-3.9%
High_R_Tint	662,103	1,029,525	281,703	147,331	2,120,662	(90,864)	-2.37	-4.5%
High_R_Clear	718,636	1,108,330	302,633	158,331	2,287,930	(258,132)	-6.72	-12.7%
189.1_3ABC	629,531	986,500	271,639	141,683	2,029,353	445	0.01	0.0%
EC_Window	597,025	943,100	256,906	134,086	1,931,117	98,681	2.57	4.9%
EC_HR_Window	607,244	960,261	262,578	137,236	1,967,319	62,479	1.63	3.1%
San Francisco - Shade OnAll - No Daylighting								
Run Description	**Cooling**	**Fans**	**Pumps**	**Cooling Tower**	**Total**	**Savings kWh**	**Savings kWh/ft²**	**% Savings**
base case	611,450	960,986	264,767	138,156	1,975,359	n.a.	n.a.	n.a.
AvgComSales	650,747	1,016,617	278,306	145,533	2,091,203	(115,844)	-3.02	-5.9%
Triple_Lowe	626,714	981,717	265,842	139,081	2,013,354	(37,995)	-0.99	-1.9%
High_R_Tint	633,547	989,572	270,825	141,617	2,035,561	(60,202)	-1.57	-3.0%
High_R_Clear	660,164	1,027,803	280,517	146,669	2,115,153	(139,794)	-3.64	-7.1%
189.1_3ABC	606,461	954,039	260,900	136,161	1,957,561	17,798	0.46	0.9%
EC_Window	586,419	931,628	254,103	132,597	1,904,747	70,612	1.84	3.6%
EC_HR_Window	596,742	949,192	259,561	135,636	1,941,131	34,228	0.89	1.7%
San Francisco - Shade OffAll - No Daylighting								
Run Description	**Cooling**	**Fans**	**Pumps**	**Cooling Tower**	**Total**	**Savings kWh**	**Savings kWh/ft²**	**% Savings**
base case	627,556	989,353	271,397	141,503	2,029,809	n.a.	n.a.	n.a.
AvgComSales	710,783	1,102,372	301,531	157,669	2,272,355	(242,546)	-6.32	-11.9%
Triple_Lowe	659,433	1,024,183	279,628	146,272	2,109,516	(79,707)	-2.08	-3.9%
High_R_Tint	662,228	1,029,694	281,483	147,186	2,120,591	(90,782)	-2.36	-4.5%
High_R_Clear	719,256	1,109,044	302,836	158,344	2,289,480	(259,671)	-6.76	-12.8%
189.1_3ABC	629,581	986,561	271,481	141,631	2,029,254	555	0.01	0.0%
EC_Window	681,647	1,063,830	290,558	151,786	2,187,821	(158,012)	-4.12	-7.8%
EC_HR_Window	675,189	1,052,128	287,986	150,172	2,165,475	(135,666)	-3.53	-6.7%

Table 54 – Electricity Savings, San Francisco, Daylighting

San Francisco - Shade OnIfHG - Daylighting									
Run Description	**Cooling**	**Fans**	**Pumps**	**Cooling Tower**	**Lighting**	**Total**	**Savings kWh**	**Savings kWh/ft²**	**% Savings**
base case	603,772	955,308	262,058	136,569	1,169,292	3,126,999	n.a.	n.a.	n.a.
AvgComSales	682,797	1,064,803	291,231	152,375	1,159,844	3,351,050	(224,051)	(5.84)	-7.2%
Triple_Lowe	632,233	987,897	270,567	141,533	1,182,842	3,215,072	(88,073)	(2.29)	-2.8%
High_R_Tint	635,086	993,222	271,914	142,186	1,177,153	3,219,561	(92,562)	(2.41)	-3.0%
High_R_Clear	689,703	1,070,036	292,978	153,200	1,162,928	3,368,845	(241,846)	(6.30)	-7.7%
189.1_3ABC	604,747	952,272	262,231	136,931	1,182,842	3,139,023	(12,024)	(0.31)	-0.4%
EC_Window	579,211	921,103	251,183	131,206	1,157,806	3,040,509	86,490	2.25	2.8%
EC_HR_Window	590,644	939,894	256,939	134,247	1,160,225	3,081,949	45,050	1.17	1.4%
San Francisco - Shade OnAll - Daylighting									
Run Description	**Cooling**	**Fans**	**Pumps**	**Cooling Tower**	**Lighting**	**Total**	**Savings kWh**	**Savings kWh/ft²**	**% Savings**
base case	588,306	928,542	255,731	133,467	1,207,083	3,113,129	n.a.	n.a.	n.a.
AvgComSales	625,325	981,900	269,042	140,592	1,191,506	3,208,365	(95,236)	(2.48)	-3.1%
Triple_Lowe	610,778	963,422	262,314	137,039	1,224,444	3,197,997	(84,868)	(2.21)	-2.7%
High_R_Tint	605,889	956,178	260,231	135,897	1,217,819	3,176,014	(62,885)	(1.64)	-2.0%
High_R_Clear	634,025	992,553	271,897	142,133	1,196,825	3,237,433	(124,304)	(3.24)	-4.0%
189.1_3ABC	588,778	933,225	254,711	132,986	1,224,444	3,134,144	(21,015)	(0.55)	-0.7%
EC_Window	579,211	921,103	251,183	131,206	1,157,806	3,040,509	72,620	1.89	2.3%
EC_HR_Window	590,644	939,894	256,939	134,247	1,160,225	3,081,949	31,180	0.81	1.0%
San Francisco - Shade OffAll - Daylighting									
Run Description	**Cooling**	**Fans**	**Pumps**	**Cooling Tower**	**Lighting**	**Total**	**Savings kWh**	**Savings kWh/ft²**	**% Savings**
base case	603,839	955,222	262,164	136,592	1,167,753	3,125,570	n.a.	n.a.	n.a.
AvgComSales	683,144	1,065,206	291,181	152,367	1,158,470	3,350,368	(224,798)	(5.86)	-7.2%
Triple_Lowe	632,364	988,019	270,692	141,536	1,181,133	3,213,744	(88,174)	(2.30)	-2.8%
High_R_Tint	635,225	993,347	272,056	142,194	1,175,508	3,218,330	(92,760)	(2.42)	-3.0%
High_R_Clear	689,936	1,070,392	293,089	153,178	1,161,500	3,368,095	(242,525)	(6.32)	-7.8%
189.1_3ABC	604,811	952,208	262,289	136,925	1,181,133	3,137,366	(11,796)	(0.31)	-0.4%
EC_Window	579,211	921,103	251,183	131,206	1,157,806	3,040,509	85,061	2.22	2.7%
EC_HR_Window	590,644	939,894	256,939	134,247	1,160,225	3,081,949	43,621	1.14	1.4%

Table 55 – Gas Savings, San Francisco, No Daylighting

San Francisco - Shade OnIfHG - No Daylighting				
Window Area=	38388			
Run Description	**Space Heating**	**Savings Therm**	**Savings kBtu/ft²**	**% Savings**
base case	12,835	n.a.	n.a.	n.a.
AvgComSales	5,635	7,201	18.76	56%
Triple_Lowe	1,823	11,013	28.69	86%
High_R_Tint	2,486	10,349	26.96	81%
High_R_Clear	2,539	10,296	26.82	80%
189.1_3ABC	5,131	7,705	20.07	60%
EC_Window	2,683	10,152	26.45	79%
EC_HR_Window	2,025	10,811	28.16	84%
San Francisco - Shade OnAll - No Daylighting				
Run Description	**Space Heating**	**Savings Therm**	**Savings kBtu/ft²**	**% Savings**
base case	4,887	n.a.	n.a.	n.a.
AvgComSales	3,125	1,762	4.59	36%
Triple_Lowe	1,625	3,263	8.50	67%
High_R_Tint	2,054	2,834	7.38	58%
High_R_Clear	1,971	2,916	7.60	60%
189.1_3ABC	3,044	1,843	4.80	38%
EC_Window	4,111	777	2.02	16%
EC_HR_Window	3,692	1,195	3.11	24%
San Francisco - Shade OffAll - No Daylighting				
Run Description	**Space Heating**	**Savings Therm**	**Savings kBtu/ft²**	**% Savings**
base case	12,820	n.a.	n.a.	n.a.
AvgComSales	5,459	7,361	19.17	57%
Triple_Lowe	1,781	11,039	28.76	86%
High_R_Tint	2,426	10,394	27.08	81%
High_R_Clear	2,438	10,382	27.04	81%
189.1_3ABC	5,079	7,740	20.16	60%
EC_Window	2,958	9,862	25.69	77%
EC_HR_Window	1,674	11,145	29.03	87%

Table 56 – Gas Savings, San Francisco, Daylighting

San Francisco - Shade OnIfHG - Daylighting				
Run Description	**Space Heating**	**Savings Therm**	**Savings kBtu/ft²**	**% Savings**
base case	15,339	n.a.	n.a.	n.a.
AvgComSales	6,895	8,443	21.99	55%
Triple_Lowe	2,314	13,025	33.93	85%
High_R_Tint	3,179	12,160	31.68	79%
High_R_Clear	3,220	12,119	31.57	79%
189.1_3ABC	6,387	8,952	23.32	58%
EC_Window	4,341	10,997	28.65	72%
EC_HR_Window	3,578	11,761	30.64	77%
San Francisco - Shade OnAll - Daylighting				
Run Description	**Space Heating**	**Savings Therm**	**Savings kBtu/ft²**	**% Savings**
base case	5,995	n.a.	n.a.	n.a.
AvgComSales	3,925	2,070	5.39	35%
Triple_Lowe	2,168	3,827	9.97	64%
High_R_Tint	2,538	3,457	9.01	58%
High_R_Clear	2,463	3,532	9.20	59%
189.1_3ABC	3,994	2,001	5.21	33%
EC_Window	4,341	1,654	4.31	28%
EC_HR_Window	3,578	2,417	6.30	40%
San Francisco - Shade OffAll - Daylighting				
Run Description	**Space Heating**	**Savings Therm**	**Savings kBtu/ft²**	**% Savings**
base case	15,335	n.a.	n.a.	n.a.
AvgComSales	6,693	8,642	22.51	56%
Triple_Lowe	2,270	13,065	34.03	85%
High_R_Tint	3,112	12,223	31.84	80%
High_R_Clear	3,094	12,241	31.89	80%
189.1_3ABC	6,341	8,994	23.43	59%
EC_Window	4,341	10,994	28.64	72%
EC_HR_Window	3,578	11,757	30.63	77%

Table 57 – Electricity Savings, Miami, No Daylighting

Miami - Shade OnIfHG - No Daylighting

Window Area= 38388

Run Description	Cooling	Fans	Pumps	Cooling Tower	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	1,663,342	1,145,480	467,161	259,489	3,535,472	n.a.	n.a.	n.a.
AvgComSales	1,826,983	1,283,881	509,667	283,114	3,903,645	(368,173)	-9.59	-10.4%
Triple_Lowe	1,728,130	1,200,097	483,925	268,817	3,680,969	(145,497)	-3.79	-4.1%
High_R_Tint	1,736,317	1,207,914	485,206	269,528	3,698,965	(163,493)	-4.26	-4.6%
High_R_Clear	1,823,622	1,281,947	508,447	282,439	3,896,455	(360,983)	-9.40	-10.2%
189.1_1AB	1,665,192	1,146,939	467,603	259,736	3,539,470	(3,998)	-0.10	-0.1%
EC_Window	1,664,597	1,154,511	471,722	262,036	3,552,866	(17,394)	-0.45	-0.5%
EC_HR_Window	1,652,617	1,151,297	471,556	261,944	3,537,414	(1,942)	-0.05	-0.1%

Miami - Shade OnAll - No Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	1,656,586	1,147,439	469,717	260,922	3,534,664	n.a.	n.a.	n.a.
AvgComSales	1,719,330	1,191,639	481,286	267,350	3,659,605	(124,941)	-3.25	-3.5%
Triple_Lowe	1,698,900	1,183,803	479,808	266,531	3,629,042	(94,378)	-2.46	-2.7%
High_R_Tint	1,698,708	1,182,019	479,192	266,186	3,626,105	(91,441)	-2.38	-2.6%
High_R_Clear	1,731,150	1,203,572	484,919	269,369	3,689,010	(154,346)	-4.02	-4.4%
189.1_1A	1,657,261	1,148,014	469,853	260,997	3,536,125	(1,461)	-0.04	0.0%
EC_Window	1,636,356	1,136,664	467,578	259,733	3,500,331	34,333	0.89	1.0%
EC_HR_Window	1,622,269	1,132,297	467,458	259,669	3,481,693	52,971	1.38	1.5%

Miami - Shade OffAll - No Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	1,662,880	1,144,339	466,750	259,261	3,533,230	n.a.	n.a.	n.a.
AvgComSales	1,829,428	1,285,400	509,914	283,250	3,907,992	(374,762)	-9.76	-10.6%
Triple_Lowe	1,729,364	1,200,947	484,106	268,917	3,683,334	(150,104)	-3.91	-4.2%
High_R_Tint	1,737,686	1,208,742	485,353	269,608	3,701,389	(168,159)	-4.38	-4.8%
High_R_Clear	1,826,453	1,283,994	508,933	282,708	3,902,088	(368,858)	-9.61	-10.4%
189.1_1AB	1,664,497	1,145,697	467,125	259,469	3,536,788	(3,558)	-0.09	-0.1%
EC_Window	1,765,192	1,238,528	495,206	275,081	3,774,007	(240,777)	-6.27	-6.8%
EC_HR_Window	1,740,694	1,216,433	488,228	271,208	3,716,563	(183,333)	-4.78	-5.2%

Table 58 – Electricity Savings, Miami, Daylighting

Miami - Shade OnIfHG - Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Lighting	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	1,625,428	1,113,094	460,408	255,728	1,168,956	4,623,614	n.a.	n.a.	n.a.
AvgComSales	1,780,842	1,246,986	499,961	277,722	1,150,553	4,956,064	(332,450)	(8.66)	-7.2%
Triple_Lowe	1,689,453	1,171,514	477,464	265,228	1,168,992	4,772,651	(149,037)	(3.88)	-3.2%
High_R_Tint	1,693,817	1,172,119	477,475	265,233	1,164,144	4,772,788	(149,174)	(3.89)	-3.2%
High_R_Clear	1,776,306	1,243,864	498,444	276,881	1,152,878	4,948,373	(324,759)	(8.46)	-7.0%
189.1_1AB	1,626,744	1,114,264	460,697	255,889	1,168,992	4,626,586	(2,972)	(0.08)	-0.1%
EC_Window	1,622,569	1,122,608	464,056	257,778	1,149,158	4,616,169	7,445	0.19	0.2%
EC_HR_Window	1,611,267	1,119,719	463,928	257,708	1,151,003	4,603,625	19,989	0.52	0.4%

Miami - Shade OnAll - Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Lighting	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	1,624,850	1,124,580	464,464	258,000	1,205,686	4,677,580	n.a.	n.a.	n.a.
AvgComSales	1,681,311	1,163,692	474,939	263,825	1,176,194	4,759,961	(82,381)	(2.15)	-1.8%
Triple_Lowe	1,664,258	1,158,642	473,994	263,300	1,205,730	4,765,924	(88,344)	(2.30)	-1.9%
High_R_Tint	1,663,689	1,156,586	473,364	262,950	1,199,325	4,755,914	(78,334)	(2.04)	-1.7%
High_R_Clear	1,692,956	1,175,486	478,550	265,831	1,180,789	4,793,612	(116,032)	(3.02)	-2.5%
189.1_1AB	1,625,642	1,125,200	464,647	258,100	1,205,730	4,679,319	(1,739)	(0.05)	0.0%
EC_Window	1,622,569	1,122,608	464,056	257,778	1,149,158	4,616,169	61,411	1.60	1.3%
EC_HR_Window	1,611,267	1,119,719	463,928	257,708	1,151,003	4,603,625	73,955	1.93	1.6%

Miami - Shade OffAll - Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Lighting	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	1,624,272	1,111,086	459,764	255,372	1,167,561	4,618,055	n.a.	n.a.	n.a.
AvgComSales	1,782,617	1,247,494	499,939	277,708	1,149,358	4,957,116	(339,061)	(8.83)	-7.3%
Triple_Lowe	1,689,847	1,171,303	477,325	265,150	1,167,594	4,771,219	(153,164)	(3.99)	-3.3%
High_R_Tint	1,694,194	1,171,875	477,306	265,139	1,162,786	4,771,300	(153,245)	(3.99)	-3.3%
High_R_Clear	1,778,714	1,245,180	498,767	277,061	1,151,653	4,951,375	(333,320)	(8.68)	-7.2%
189.1_1AB	1,625,583	1,112,258	460,044	255,528	1,167,594	4,621,007	(2,952)	(0.08)	-0.1%
EC_Window	1,622,569	1,122,608	464,056	257,778	1,149,158	4,616,169	1,886	0.05	0.0%
EC_HR_Window	1,611,267	1,119,719	463,928	257,708	1,151,003	4,603,625	14,430	0.38	0.3%

Table 59 – Gas Savings, Miami, No Daylighting

Miami - Shade OnIfHG - No Daylighting

Window Area= 38388

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	523	n.a.	n.a.	n.a.
AvgComSales	217	306	0.80	58%
Triple_Lowe	73	450	1.17	86%
High_R_Tint	93	430	1.12	82%
High_R_Clear	95	428	1.11	82%
189.1_1AB	509	14	0.04	3%
EC_Window	104	419	1.09	80%
EC_HR_Window	73	451	1.17	86%

Miami - Shade OnAll - No Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	204	n.a.	n.a.	n.a.
AvgComSales	108	96	0.25	47%
Triple_Lowe	76	128	0.33	63%
High_R_Tint	88	116	0.30	57%
High_R_Clear	74	130	0.34	64%
189.1_1AB	201	3	0.01	1%
EC_Window	144	60	0.16	29%
EC_HR_Window	111	93	0.24	46%

Miami - Shade OffAll - No Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	513	n.a.	n.a.	n.a.
AvgComSales	206	307	0.80	60%
Triple_Lowe	71	442	1.15	86%
High_R_Tint	90	423	1.10	82%
High_R_Clear	91	423	1.10	82%
189.1_1AB	499	14	0.04	3%
EC_Window	101	412	1.07	80%
EC_HR_Window	57	456	1.19	89%

Table 60 – Gas Savings, Miami, Daylighting

Miami - Shade OnIfHG - Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	629	n.a.	n.a.	n.a.
AvgComSales	271	358	0.93	57%
Triple_Lowe	100	529	1.38	84%
High_R_Tint	125	504	1.31	80%
High_R_Clear	123	506	1.32	80%
189.1_1AB	612	17	0.04	3%
EC_Window	153	476	1.24	76%
EC_HR_Window	110	519	1.35	83%

Miami - Shade OnAll - Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	247	n.a.	n.a.	n.a.
AvgComSales	137	110	0.29	44%
Triple_Lowe	93	154	0.40	62%
High_R_Tint	108	140	0.36	56%
High_R_Clear	94	153	0.40	62%
189.1_1AB	244	4	0.01	1%
EC_Window	153	94	0.25	38%
EC_HR_Window	110	137	0.36	56%

Miami - Shade OffAll - Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	611	n.a.	n.a.	n.a.
AvgComSales	254	357	0.93	58%
Triple_Lowe	95	516	1.34	84%
High_R_Tint	119	492	1.28	81%
High_R_Clear	115	496	1.29	81%
189.1_1AB	594	17	0.04	3%
EC_Window	153	458	1.19	75%
EC_HR_Window	110	501	1.30	82%

Table 61 – Electricity Savings, Phoenix, No Daylighting

Phoenix - Shade OnIfHG - No Daylighting

Window Area= 38388

Run Description	Cooling	Fans	Pumps	Cooling Tower	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	1,286,656	1,417,478	426,742	230,269	3,361,145	n.a.	n.a.	n.a.
AvgComSales	1,410,358	1,549,469	459,092	249,172	3,668,091	(306,946)	-8.00	-9.1%
Triple_Lowe	1,291,736	1,426,906	425,514	230,544	3,374,700	(13,555)	-0.35	-0.4%
High_R_Tint	1,304,919	1,437,269	428,383	232,097	3,402,668	(41,523)	-1.08	-1.2%
High_R_Clear	1,384,783	1,522,528	451,031	244,925	3,603,267	(242,122)	-6.31	-7.2%
189.1_2ABC	1,288,883	1,421,286	427,747	230,961	3,368,877	(7,732)	-0.20	-0.2%
EC_Window	1,230,422	1,375,780	415,686	224,469	3,246,357	114,788	2.99	3.4%
EC_HR_Window	1,203,497	1,354,758	410,500	221,669	3,190,424	170,721	4.45	5.1%

Phoenix - Shade OnAll - No Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	1,242,406	1,385,344	418,558	225,953	3,272,261	n.a.	n.a.	n.a.
AvgComSales	1,292,414	1,427,706	426,814	231,086	3,378,020	(105,759)	-2.76	-3.2%
Triple_Lowe	1,255,967	1,399,442	420,256	227,314	3,302,979	(30,718)	-0.80	-0.9%
High_R_Tint	1,260,586	1,402,594	421,267	227,789	3,312,236	(39,975)	-1.04	-1.2%
High_R_Clear	1,290,458	1,427,744	425,853	230,736	3,374,791	(102,530)	-2.67	-3.1%
189.1_2ABC	1,246,861	1,389,944	419,772	226,683	3,283,260	(10,999)	-0.29	-0.3%
EC_Window	1,206,156	1,355,164	410,267	221,467	3,193,054	79,207	2.06	2.4%
EC_HR_Window	1,175,730	1,331,406	404,308	218,303	3,129,747	142,514	3.71	4.4%

Phoenix - Shade OffAll - No Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	1,287,633	1,418,242	426,994	230,411	3,363,280	n.a.	n.a.	n.a.
AvgComSales	1,413,789	1,552,789	460,094	249,681	3,676,353	(313,073)	-8.16	-9.3%
Triple_Lowe	1,293,414	1,428,600	426,097	230,833	3,378,944	(15,664)	-0.41	-0.5%
High_R_Tint	1,306,497	1,438,842	428,733	232,269	3,406,341	(43,061)	-1.12	-1.3%
High_R_Clear	1,387,850	1,525,619	451,975	245,369	3,610,813	(247,533)	-6.45	-7.4%
189.1_2ABC	1,290,219	1,422,511	428,150	231,150	3,372,030	(8,750)	-0.23	-0.3%
EC_Window	1,328,367	1,472,058	437,672	237,400	3,475,497	(112,217)	-2.92	-3.3%
EC_HR_Window	1,285,486	1,423,942	422,744	229,450	3,361,622	1,658	0.04	0.0%

Table 62 – Electricity Savings, Phoenix, Daylighting

Phoenix - Shade OnIfHG - Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Lighting	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	1,258,339	1,391,256	420,081	226,667	1,170,622	4,466,965	n.a.	n.a.	n.a.
AvgComSales	1,372,264	1,510,094	449,228	243,714	1,150,428	4,725,728	(258,763)	(6.74)	-5.8%
Triple_Lowe	1,258,617	1,396,239	419,014	226,803	1,170,661	4,471,334	(4,369)	(0.11)	-0.1%
High_R_Tint	1,271,483	1,406,353	421,528	228,206	1,165,553	4,493,123	(26,158)	(0.68)	-0.6%
High_R_Clear	1,345,400	1,481,947	441,058	239,317	1,153,050	4,660,772	(193,807)	(5.05)	-4.3%
189.1_2ABC	1,258,347	1,393,233	420,436	226,997	1,170,661	4,469,674	(2,709)	(0.07)	-0.1%
EC_Window	1,196,286	1,342,522	406,861	219,681	1,149,061	4,314,411	152,554	3.97	3.4%
EC_HR_Window	1,169,061	1,321,089	401,442	216,778	1,151,183	4,259,553	207,412	5.40	4.6%

Phoenix - Shade OnAll - Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Lighting	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	1,216,956	1,362,275	412,697	222,786	1,210,233	4,424,947	n.a.	n.a.	n.a.
AvgComSales	1,261,772	1,399,811	421,039	227,736	1,180,528	4,490,886	(65,939)	(1.72)	-1.5%
Triple_Lowe	1,227,806	1,373,833	415,289	224,422	1,210,275	4,451,625	(26,678)	(0.69)	-0.6%
High_R_Tint	1,232,664	1,377,264	416,425	224,992	1,204,200	4,455,545	(30,598)	(0.80)	-0.7%
High_R_Clear	1,258,561	1,398,464	419,669	227,161	1,185,344	4,489,199	(64,252)	(1.67)	-1.5%
189.1_2ABC	1,220,908	1,366,661	413,822	223,469	1,210,275	4,435,135	(10,188)	(0.27)	-0.2%
EC_Window	1,196,286	1,342,522	406,861	219,681	1,149,061	4,314,411	110,536	2.88	2.5%
EC_HR_Window	1,169,061	1,321,089	401,442	216,778	1,151,183	4,259,553	165,394	4.31	3.7%

Phoenix - Shade OffAll - Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Lighting	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	1,258,430	1,390,564	419,869	226,547	1,169,622	4,465,032	n.a.	n.a.	n.a.
AvgComSales	1,374,150	1,511,047	449,353	243,753	1,149,603	4,727,906	(262,874)	(6.85)	-5.9%
Triple_Lowe	1,258,914	1,395,880	418,781	226,678	1,169,658	4,469,911	(4,879)	(0.13)	-0.1%
High_R_Tint	1,272,053	1,406,253	421,417	228,089	1,164,592	4,492,404	(27,372)	(0.71)	-0.6%
High_R_Clear	1,347,197	1,483,003	441,328	239,522	1,152,206	4,663,256	(198,224)	(5.16)	-4.4%
189.1_2ABC	1,258,500	1,392,675	420,308	226,908	1,169,658	4,468,049	(3,017)	(0.08)	-0.1%
EC_Window	1,196,286	1,342,522	406,861	219,681	1,149,061	4,314,411	150,621	3.92	3.4%
EC_HR_Window	1,169,061	1,321,089	401,442	216,778	1,151,183	4,259,553	205,479	5.35	4.6%

Table 63 – Gas Savings, Phoenix, No Daylighting

Phoenix - Shade OnIfHG - No Daylighting

Window Area= 38388

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	8,814	n.a.	n.a.	n.a.
AvgComSales	5,015	3,799	9.90	43%
Triple_Lowe	2,886	5,928	15.44	67%
High_R_Tint	3,330	5,484	14.29	62%
High_R_Clear	3,178	5,636	14.68	64%
189.1_2ABC	6,215	2,599	6.77	29%
EC_Window	3,874	4,940	12.87	56%
EC_HR_Window	3,070	5,744	14.96	65%

Phoenix - Shade OnAll - No Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	5,583	n.a.	n.a.	n.a.
AvgComSales	3,678	1,905	4.96	34%
Triple_Lowe	2,932	2,650	6.90	47%
High_R_Tint	3,242	2,341	6.10	42%
High_R_Clear	2,870	2,713	7.07	49%
189.1_2ABC	4,712	871	2.27	16%
EC_Window	4,592	990	2.58	18%
EC_HR_Window	3,931	1,652	4.30	30%

Phoenix - Shade OffAll - No Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	8,769	n.a.	n.a.	n.a.
AvgComSales	4,796	3,973	10.35	45%
Triple_Lowe	2,812	5,958	15.52	68%
High_R_Tint	3,238	5,531	14.41	63%
High_R_Clear	3,032	5,737	14.95	65%
189.1_2ABC	6,132	2,637	6.87	30%
EC_Window	3,301	5,468	14.24	62%
EC_HR_Window	2,268	6,502	16.94	74%

Table 64 – Gas Savings, Phoenix, Daylighting

Phoenix - Shade OnIfHG - Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	9,838	n.a.	n.a.	n.a.
AvgComSales	5,757	4,081	10.63	41%
Triple_Lowe	3,453	6,385	16.63	65%
High_R_Tint	3,973	5,865	15.28	60%
High_R_Clear	3,768	6,070	15.81	62%
189.1_2ABC	7,100	2,738	7.13	28%
EC_Window	4,834	5,004	13.04	51%
EC_HR_Window	3,997	5,841	15.22	59%

Phoenix - Shade OnAll - Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	6,265	n.a.	n.a.	n.a.
AvgComSales	4,259	2,006	5.23	32%
Triple_Lowe	3,357	2,908	7.57	46%
High_R_Tint	3,715	2,550	6.64	41%
High_R_Clear	3,343	2,922	7.61	47%
189.1_2ABC	5,319	946	2.47	15%
EC_Window	4,834	1,431	3.73	23%
EC_HR_Window	3,997	2,268	5.91	36%

Phoenix - Shade OffAll - Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	9,748	n.a.	n.a.	n.a.
AvgComSales	5,462	4,287	11.17	44%
Triple_Lowe	3,332	6,416	16.71	66%
High_R_Tint	3,828	5,920	15.42	61%
High_R_Clear	3,560	6,189	16.12	63%
189.1_2ABC	6,971	2,778	7.24	28%
EC_Window	4,834	4,915	12.80	50%
EC_HR_Window	3,997	5,752	14.98	59%

Table 65 – Electricity Savings, Chicago, No Daylighting

Chicago - Shade OnIfHG - No Daylighting

Window Area= 38388

Run Description	Cooling	Fans	Pumps	Cooling Tower	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	738,592	1,262,980	360,744	136,667	2,498,983	n.a.	n.a.	n.a.
AvgComSales	786,994	1,334,906	382,847	143,897	2,648,644	(149,661)	-3.90	-6.0%
Triple_Lowe	725,717	1,195,917	352,550	133,878	2,408,062	90,921	2.37	3.6%
High_R_Tint	732,642	1,220,681	356,786	135,214	2,445,323	53,660	1.40	2.1%
High_R_Clear	786,378	1,290,764	379,078	143,003	2,599,223	(100,240)	-2.61	-4.0%
189.1_5ABC	748,633	1,261,747	364,575	137,981	2,512,936	(13,953)	-0.36	-0.6%
EC_Window	681,714	1,147,603	335,456	128,492	2,293,265	205,718	5.36	8.2%
EC_HR_Window	681,586	1,130,233	337,011	128,872	2,277,702	221,281	5.76	8.9%

Chicago - Shade OnAll - No Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	699,269	1,178,267	343,042	130,642	2,351,220	n.a.	n.a.	n.a.
AvgComSales	715,783	1,200,453	349,075	132,803	2,398,114	(46,894)	-1.22	-2.0%
Triple_Lowe	706,186	1,167,522	346,172	131,617	2,351,497	(277)	-0.01	0.0%
High_R_Tint	703,536	1,169,592	344,725	131,153	2,349,006	2,214	0.06	0.1%
High_R_Clear	724,622	1,195,820	352,547	133,867	2,406,856	(55,636)	-1.45	-2.4%
189.1_5ABC	703,967	1,177,689	344,344	131,067	2,357,067	(5,847)	-0.15	-0.2%
EC_Window	666,628	1,134,019	330,083	126,758	2,257,488	93,732	2.44	4.0%
EC_HR_Window	663,264	1,112,308	330,233	126,617	2,232,422	118,798	3.09	5.1%

Chicago - Shade OffAll - No Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	738,722	1,262,361	360,667	136,622	2,498,372	n.a.	n.a.	n.a.
AvgComSales	787,686	1,334,803	383,531	143,928	2,649,948	(151,576)	-3.95	-6.1%
Triple_Lowe	726,083	1,195,956	352,728	133,967	2,408,734	89,638	2.34	3.6%
High_R_Tint	733,258	1,221,047	357,061	135,286	2,446,652	51,720	1.35	2.1%
High_R_Clear	787,464	1,291,264	379,447	143,100	2,601,275	(102,903)	-2.68	-4.1%
189.1_5ABC	748,978	1,261,614	364,781	138,011	2,513,384	(15,012)	-0.39	-0.6%
EC_Window	740,886	1,228,078	359,867	136,372	2,465,203	33,169	0.86	1.3%
EC_HR_Window	736,206	1,200,367	357,794	135,825	2,430,192	68,180	1.78	2.7%

Table 66 – Electricity Savings, Chicago, Daylighting

Chicago - Shade OnIfHG - Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Lighting	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	704,578	1,211,083	344,353	131,267	1,170,120	3,561,401	n.a.	n.a.	n.a.
AvgComSales	751,953	1,283,892	366,392	138,672	1,168,461	3,709,370	(147,969)	(3.85)	-4.2%
Triple_Lowe	691,619	1,145,436	337,967	129,158	1,197,300	3,501,480	59,921	1.56	1.7%
High_R_Tint	695,933	1,163,628	339,606	129,872	1,190,697	3,519,736	41,665	1.09	1.2%
High_R_Clear	748,125	1,236,819	362,686	137,603	1,172,592	3,657,825	(96,424)	(2.51)	-2.7%
189.1_5ABC	713,350	1,209,536	348,097	132,656	1,179,647	3,583,286	(21,885)	(0.57)	-0.6%
EC_Window	650,436	1,099,917	320,489	123,917	1,165,961	3,360,720	200,681	5.23	5.6%
EC_HR_Window	648,647	1,081,061	321,039	124,011	1,169,267	3,344,025	217,376	5.66	6.1%

Chicago - Shade OnAll - Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Lighting	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	670,867	1,135,497	329,997	126,739	1,213,100	3,476,200	n.a.	n.a.	n.a.
AvgComSales	686,069	1,156,964	335,783	128,656	1,205,267	3,512,739	(36,539)	(0.95)	-1.1%
Triple_Lowe	681,622	1,133,020	335,725	128,422	1,239,442	3,518,231	(42,031)	(1.09)	-1.2%
High_R_Tint	678,892	1,134,608	334,336	127,978	1,232,539	3,508,353	(32,153)	(0.84)	-0.9%
High_R_Clear	692,531	1,148,758	338,708	129,386	1,210,889	3,520,272	(44,072)	(1.15)	-1.3%
189.1_5ABC	677,572	1,139,603	332,806	127,642	1,219,792	3,497,415	(21,215)	(0.55)	-0.6%
EC_Window	650,436	1,099,917	320,489	123,917	1,165,961	3,360,720	115,480	3.01	3.3%
EC_HR_Window	648,647	1,081,061	321,039	124,011	1,169,267	3,344,025	132,175	3.44	3.8%

Chicago - Shade OffAll - Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Lighting	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	704,611	1,210,186	344,325	131,169	1,167,631	3,557,922	n.a.	n.a.	n.a.
AvgComSales	752,250	1,283,311	366,711	138,639	1,166,136	3,707,047	(149,125)	(3.88)	-4.2%
Triple_Lowe	691,783	1,145,000	338,078	129,186	1,195,297	3,499,344	58,578	1.53	1.6%
High_R_Tint	695,756	1,162,739	339,481	129,814	1,188,622	3,516,412	41,510	1.08	1.2%
High_R_Clear	748,697	1,236,292	362,869	137,514	1,170,308	3,655,680	(97,758)	(2.55)	-2.7%
189.1_5ABC	713,169	1,208,297	348,017	132,603	1,177,442	3,579,528	(21,606)	(0.56)	-0.6%
EC_Window	650,436	1,099,917	320,489	123,917	1,165,961	3,360,720	197,202	5.14	5.5%
EC_HR_Window	648,647	1,081,061	321,039	124,011	1,169,267	3,344,025	213,897	5.57	6.0%

Table 67 – Gas Savings, Chicago, No Daylighting

Chicago - Shade OnIfHG - No Daylighting

Window Area= 38388

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	39,537	n.a.	n.a.	n.a.
AvgComSales	39,362	175	0.46	0%
Triple_Lowe	24,136	15,401	40.12	39%
High_R_Tint	28,234	11,304	29.45	29%
High_R_Clear	26,544	12,994	33.85	33%
189.1_5ABC	34,318	5,219	13.59	13%
EC_Window	29,697	9,840	25.63	25%
EC_HR_Window	22,785	16,752	43.64	42%

Chicago - Shade OnAll - No Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	31,042	n.a.	n.a.	n.a.
AvgComSales	30,548	494	1.29	2%
Triple_Lowe	23,247	7,795	20.31	25%
High_R_Tint	25,616	5,426	14.13	17%
High_R_Clear	24,291	6,751	17.59	22%
189.1_5ABC	28,611	2,431	6.33	8%
EC_Window	32,601	(1,560)	-4.06	-5%
EC_HR_Window	25,896	5,146	13.40	17%

Chicago - Shade OffAll - No Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	39,339	n.a.	n.a.	n.a.
AvgComSales	38,981	358	0.93	1%
Triple_Lowe	23,923	15,416	40.16	39%
High_R_Tint	28,014	11,326	29.50	29%
High_R_Clear	26,102	13,237	34.48	34%
189.1_5ABC	34,061	5,279	13.75	13%
EC_Window	26,905	12,434	32.39	32%
EC_HR_Window	19,866	19,474	50.73	50%

Table 68 – Gas Savings, Chicago, Daylighting

Chicago - Shade OnIfHG - Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	42,573	n.a.	n.a.	n.a.
AvgComSales	42,107	466	1.21	1%
Triple_Lowe	25,797	16,775	43.70	39%
High_R_Tint	30,076	12,497	32.55	29%
High_R_Clear	28,598	13,975	36.40	33%
189.1_5ABC	36,625	5,948	15.49	14%
EC_Window	32,810	9,762	25.43	23%
EC_HR_Window	25,469	17,104	44.55	40%

Chicago - Shade OnAll - Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	33,004	n.a.	n.a.	n.a.
AvgComSales	32,549	454	1.18	1%
Triple_Lowe	24,770	8,234	21.45	25%
High_R_Tint	27,331	5,673	14.78	17%
High_R_Clear	25,840	7,163	18.66	22%
189.1_5ABC	30,543	2,461	6.41	7%
EC_Window	32,810	193	0.50	1%
EC_HR_Window	25,469	7,535	19.63	23%

Chicago - Shade OffAll - Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	42,448	n.a.	n.a.	n.a.
AvgComSales	41,772	677	1.76	2%
Triple_Lowe	25,598	16,851	43.90	40%
High_R_Tint	29,849	12,600	32.82	30%
High_R_Clear	28,142	14,306	37.27	34%
189.1_5ABC	36,361	6,087	15.86	14%
EC_Window	32,810	9,638	25.11	23%
EC_HR_Window	25,469	16,980	44.23	40%

Table 69 – Electricity Savings, Duluth, No Daylighting

Duluth - Shade OnIfHG - No Daylighting

Window Area= 38388

Run Description	Cooling	Fans	Pumps	Cooling Tower	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	523,767	1,340,217	307,889	97,392	2,269,265	n.a.	n.a.	n.a.
AvgComSales	537,747	1,367,958	316,361	99,339	2,321,405	(52,140)	-1.36	-2.3%
Triple_Lowe	484,292	1,208,703	285,942	91,636	2,070,573	198,692	5.18	8.8%
High_R_Tint	484,800	1,229,500	285,436	91,819	2,091,555	177,710	4.63	7.8%
High_R_Clear	543,461	1,316,361	319,508	99,708	2,279,038	(9,773)	-0.25	-0.4%
189.1_7	547,447	1,335,986	321,900	100,381	2,305,714	(36,449)	-0.95	-1.6%
EC_Window	432,175	1,137,372	253,031	84,631	1,907,209	362,056	9.43	16.0%
EC_HR_Window	436,572	1,117,936	257,636	85,839	1,897,983	371,282	9.67	16.4%

Duluth - Shade OnAll - No Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	465,286	1,204,720	272,636	89,133	2,031,775	n.a.	n.a.	n.a.
AvgComSales	470,819	1,216,650	276,656	89,889	2,054,014	(22,239)	-0.58	-1.1%
Triple_Lowe	458,119	1,159,883	268,894	88,092	1,974,988	56,787	1.48	2.8%
High_R_Tint	455,492	1,166,381	266,667	87,800	1,976,340	55,435	1.44	2.7%
High_R_Clear	481,456	1,205,633	283,694	91,200	2,061,983	(30,208)	-0.79	-1.5%
189.1_3ABC	480,964	1,212,003	282,997	91,172	2,067,136	(35,361)	-0.92	-1.7%
EC_Window	422,519	1,125,444	248,200	83,372	1,879,535	152,240	3.97	7.5%
EC_HR_Window	422,250	1,102,483	249,139	84,119	1,857,991	173,784	4.53	8.6%

Duluth - Shade OffAll - No Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	524,661	1,340,786	308,381	97,450	2,271,278	n.a.	n.a.	n.a.
AvgComSales	538,606	1,368,170	316,653	99,319	2,322,748	(51,470)	-1.34	-2.3%
Triple_Lowe	484,719	1,208,725	286,339	91,683	2,071,466	199,812	5.21	8.8%
High_R_Tint	485,242	1,229,230	285,656	91,864	2,091,992	179,286	4.67	7.9%
High_R_Clear	544,928	1,316,658	320,792	99,892	2,282,270	(10,992)	-0.29	-0.5%
189.1_3ABC	548,833	1,336,453	323,194	100,575	2,309,055	(37,777)	-0.98	-1.7%
EC_Window	499,589	1,250,314	294,833	93,994	2,138,730	132,548	3.45	5.8%
EC_HR_Window	491,836	1,195,919	290,489	92,439	2,070,683	200,595	5.23	8.8%

Table 70 – Electricity Savings, Duluth, Daylighting

Duluth - Shade OnIfHG - Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Lighting	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	492,258	1,286,797	288,692	92,783	1,174,767	3,335,297	n.a.	n.a.	n.a.
AvgComSales	505,339	1,312,583	296,489	94,617	1,172,025	3,381,053	(45,756)	(1.19)	-1.4%
Triple_Lowe	451,367	1,155,219	263,761	87,211	1,204,317	3,161,875	173,422	4.52	5.2%
High_R_Tint	454,336	1,177,617	265,194	87,608	1,197,033	3,181,788	153,509	4.00	4.6%
High_R_Clear	507,242	1,261,797	298,281	94,989	1,176,847	3,339,156	(3,859)	(0.10)	-0.1%
189.1_7	512,336	1,282,503	300,950	95,681	1,174,261	3,365,731	(30,434)	(0.79)	-0.9%
EC_Window	410,658	1,093,525	238,686	81,164	1,168,994	2,993,027	342,270	8.92	10.3%
EC_HR_Window	409,661	1,071,186	239,203	81,964	1,172,872	2,974,886	360,411	9.39	10.8%

Duluth - Shade OnAll - Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Lighting	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	439,439	1,157,494	256,294	85,264	1,222,528	3,161,019	n.a.	n.a.	n.a.
AvgComSales	443,114	1,166,789	258,931	85,825	1,212,947	3,167,606	(6,587)	(0.17)	-0.2%
Triple_Lowe	435,806	1,123,094	255,386	85,269	1,247,661	3,147,216	13,803	0.36	0.4%
High_R_Tint	431,967	1,125,336	252,178	84,669	1,241,030	3,135,180	25,839	0.67	0.8%
High_R_Clear	448,875	1,151,078	261,753	86,725	1,218,994	3,167,425	(6,406)	(0.17)	-0.2%
189.1_3ABC	450,711	1,160,853	262,956	86,981	1,215,778	3,177,279	(16,260)	(0.42)	-0.5%
EC_Window	410,658	1,093,525	238,686	81,164	1,168,994	2,993,027	167,992	4.38	5.3%
EC_HR_Window	409,661	1,071,186	239,203	81,964	1,172,872	2,974,886	186,133	4.85	5.9%

Duluth - Shade OffAll - Daylighting

Run Description	Cooling	Fans	Pumps	Cooling Tower	Lighting	Total	Savings kWh	Savings kWh/ft²	% Savings
base case	492,711	1,286,678	288,797	92,794	1,172,342	3,333,322	n.a.	n.a.	n.a.
AvgComSales	505,833	1,312,530	296,625	94,647	1,169,764	3,379,399	(46,077)	(1.20)	-1.4%
Triple_Lowe	451,494	1,154,606	263,711	87,139	1,202,094	3,159,044	174,278	4.54	5.2%
High_R_Tint	454,306	1,176,583	265,111	87,528	1,194,786	3,178,314	155,008	4.04	4.7%
High_R_Clear	507,747	1,260,625	298,697	94,964	1,174,583	3,336,616	(3,294)	(0.09)	-0.1%
189.1_3ABC	513,014	1,281,497	301,486	95,708	1,171,994	3,363,699	(30,377)	(0.79)	-0.9%
EC_Window	410,658	1,093,525	238,686	81,164	1,168,994	2,993,027	340,295	8.86	10.2%
EC_HR_Window	409,661	1,071,186	239,203	81,964	1,172,872	2,974,886	358,436	9.34	10.8%

Table 71 – Gas Savings, Duluth, No Daylighting

Duluth - Shade OnIfHG - No Daylighting

Window Area= 38388

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	63,889	n.a.	n.a.	n.a.
AvgComSales	65,372	(1,483)	-3.86	-2%
Triple_Lowe	40,592	23,297	60.69	36%
High_R_Tint	47,022	16,867	43.94	26%
High_R_Clear	44,123	19,765	51.49	31%
189.1_7	47,957	15,931	41.50	25%
EC_Window	50,830	13,059	34.02	20%
EC_HR_Window	38,431	25,457	66.32	40%

Duluth - Shade OnAll - No Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	50,859	n.a.	n.a.	n.a.
AvgComSales	51,613	(754)	-1.96	-1%
Triple_Lowe	38,895	11,964	31.17	24%
High_R_Tint	43,013	7,846	20.44	15%
High_R_Clear	40,902	9,957	25.94	20%
189.1_3ABC	43,164	7,695	20.04	15%
EC_Window	55,498	(4,639)	-12.08	-9%
EC_HR_Window	43,128	7,732	20.14	15%

Duluth - Shade OffAll - No Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	63,405	n.a.	n.a.	n.a.
AvgComSales	64,870	(1,465)	-3.82	-2%
Triple_Lowe	40,260	23,145	60.29	37%
High_R_Tint	46,667	16,738	43.60	26%
High_R_Clear	43,416	19,989	52.07	32%
189.1_3ABC	47,229	16,176	42.14	26%
EC_Window	45,344	18,061	47.05	28%
EC_HR_Window	33,101	30,304	78.94	48%

Table 72 – Gas Savings, Duluth, Daylighting

Duluth - Shade OnIfHG - Daylighting

Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	68,386	n.a.	n.a.	n.a.
AvgComSales	69,805	(1,419)	-3.70	-2%
Triple_Lowe	43,568	24,819	64.65	36%
High_R_Tint	50,635	17,752	46.24	26%
High_R_Clear	47,568	20,818	54.23	30%
189.1_7	51,745	16,641	43.35	24%
EC_Window	56,920	11,466	29.87	17%
EC_HR_Window	43,120	25,266	65.82	37%

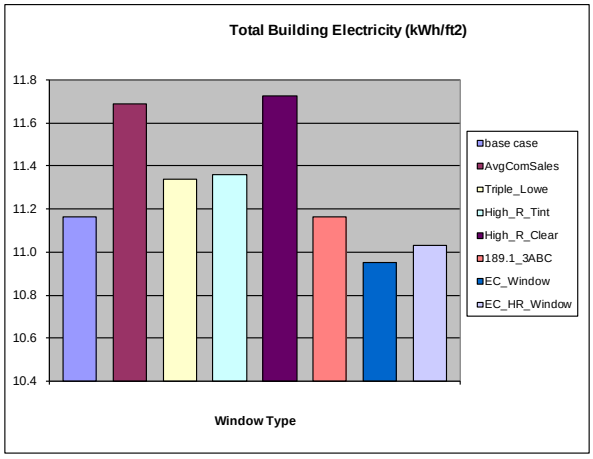
Duluth - Shade OnAll - Daylighting

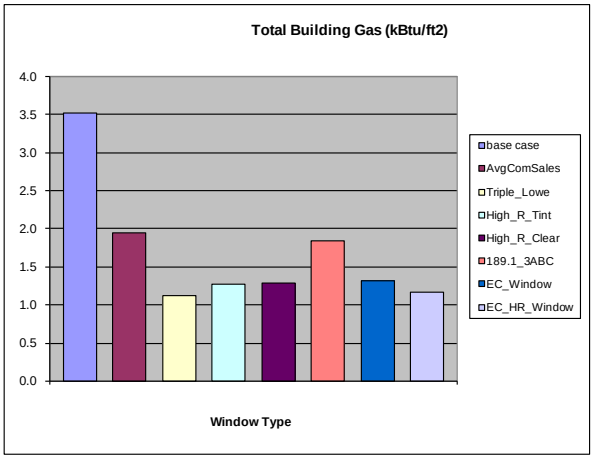
Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	54,513	n.a.	n.a.	n.a.
AvgComSales	55,332	(819)	-2.13	-2%
Triple_Lowe	41,517	12,996	33.85	24%
High_R_Tint	46,007	8,506	22.16	16%
High_R_Clear	43,780	10,733	27.96	20%
189.1_3ABC	46,340	8,173	21.29	15%
EC_Window	56,920	(2,408)	-6.27	-4%
EC_HR_Window	43,120	11,392	29.68	21%

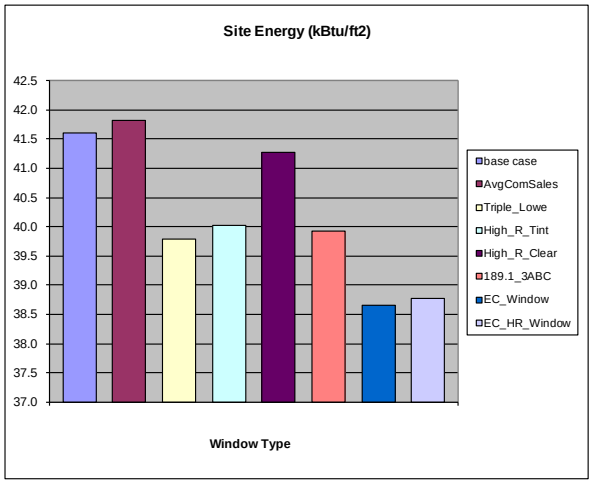
Duluth - Shade OffAll - Daylighting

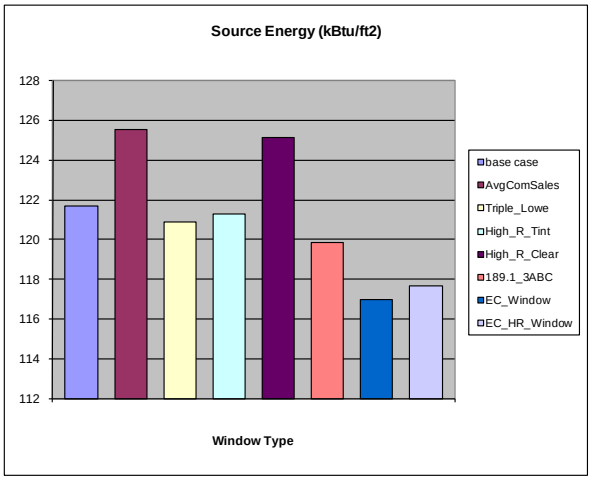
Run Description	Space Heating	Savings Therm	Savings kBtu/ft²	% Savings
base case	67,944	n.a.	n.a.	n.a.
AvgComSales	69,339	(1,394)	-3.63	-2%
Triple_Lowe	43,291	24,654	64.22	36%
High_R_Tint	50,362	17,583	45.80	26%
High_R_Clear	46,919	21,026	54.77	31%
189.1_3ABC	51,044	16,901	44.03	25%
EC_Window	56,920	11,024	28.72	16%
EC_HR_Window	43,120	24,824	64.67	37%

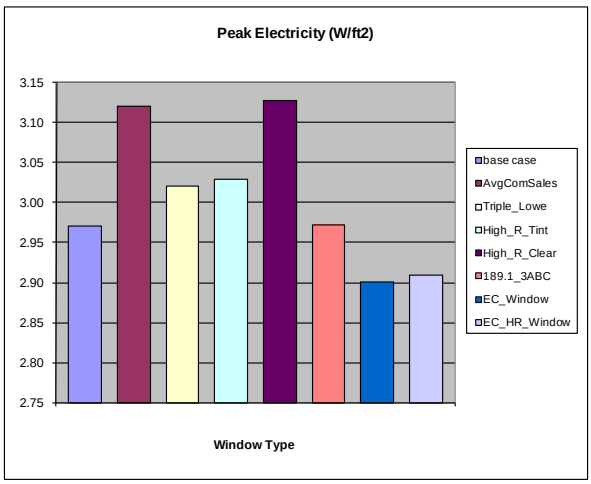
Figure 14 - For San Francisco – Shades on if high glare, no daylighting controls

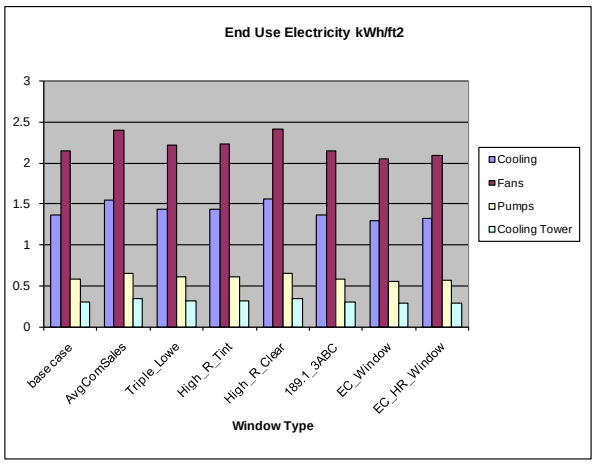


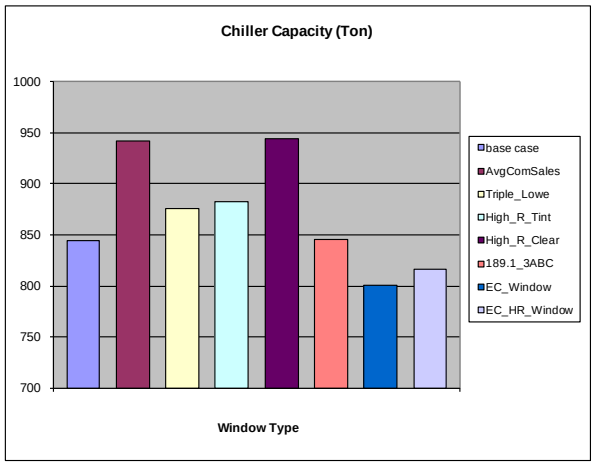


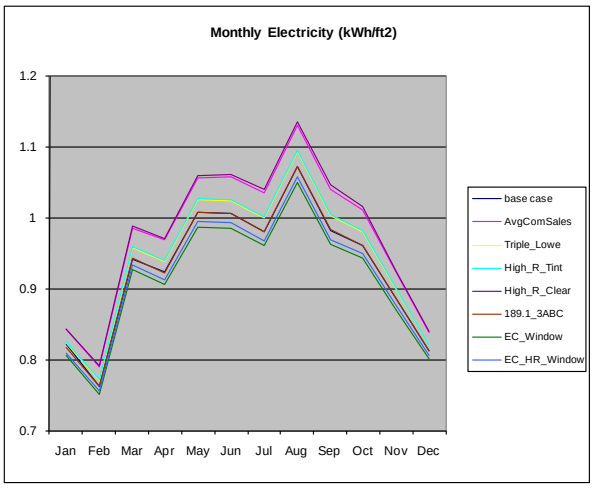


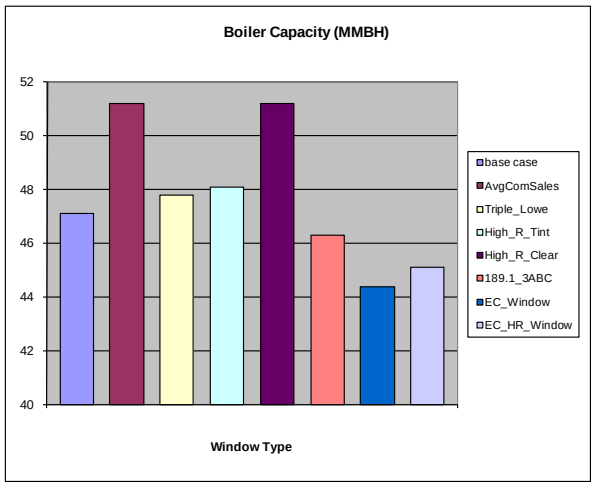





End Use Electricity kWh/ft2
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1000
950
900
850
800
750
700
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.2
1.1
1
0.9
0.8
0.7
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
52
50
48
46
44
42
40
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

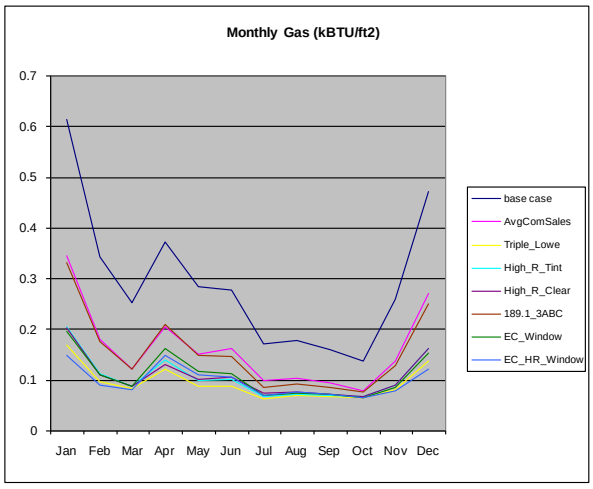
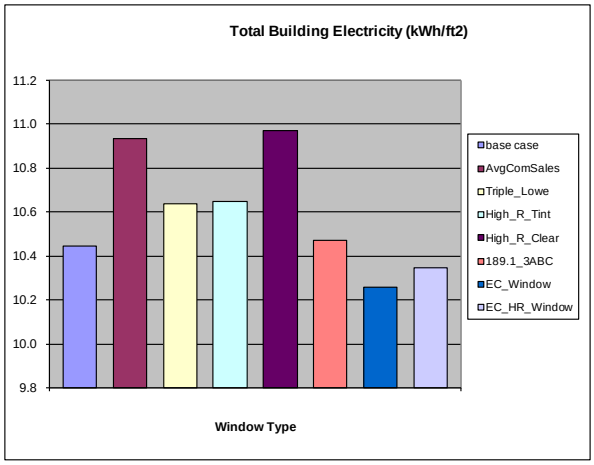
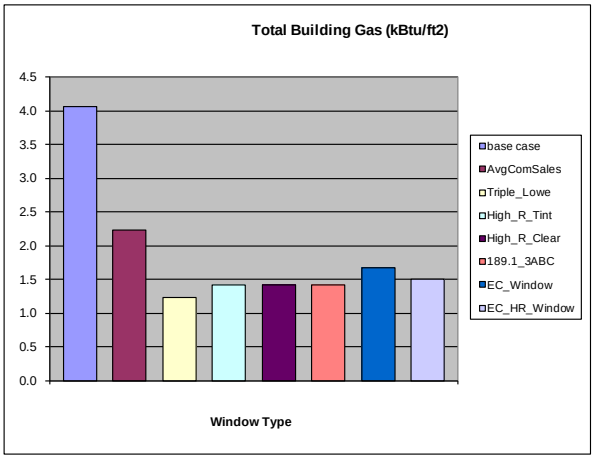
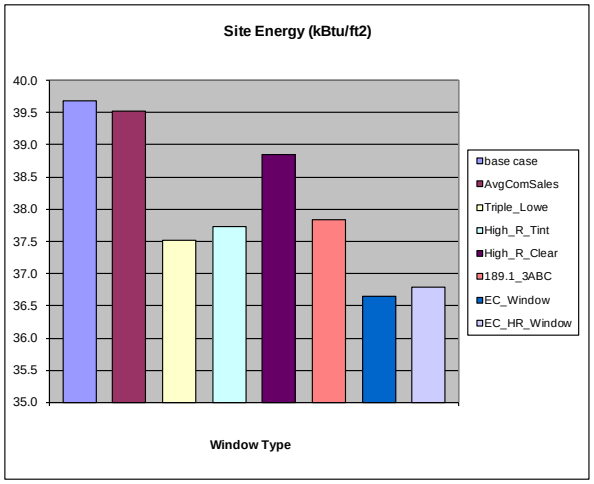
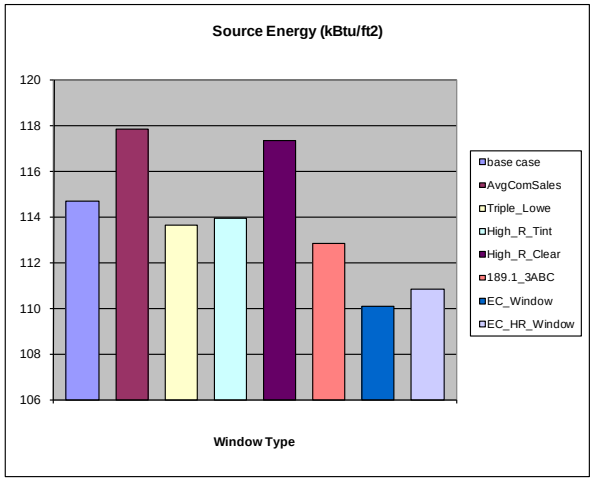

Monthly Gas (kBTU/ft2)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

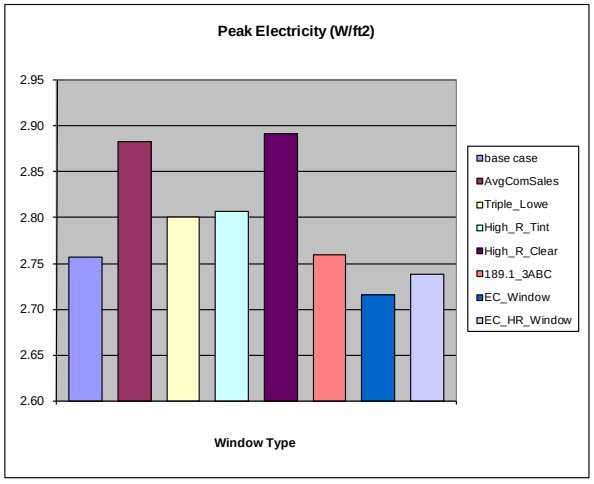
Figure 15 - For San Francisco – Shades on if high glare, with daylighting controls

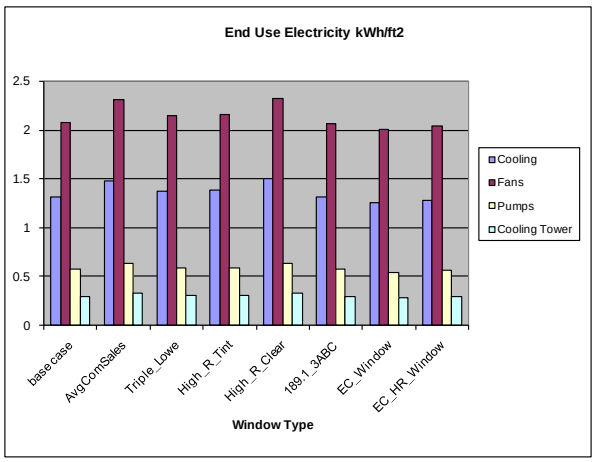


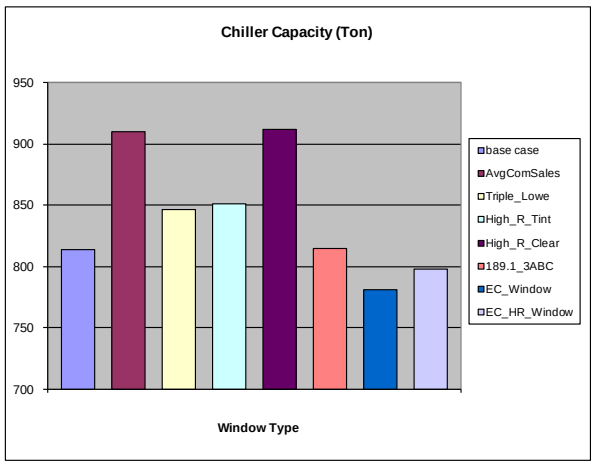


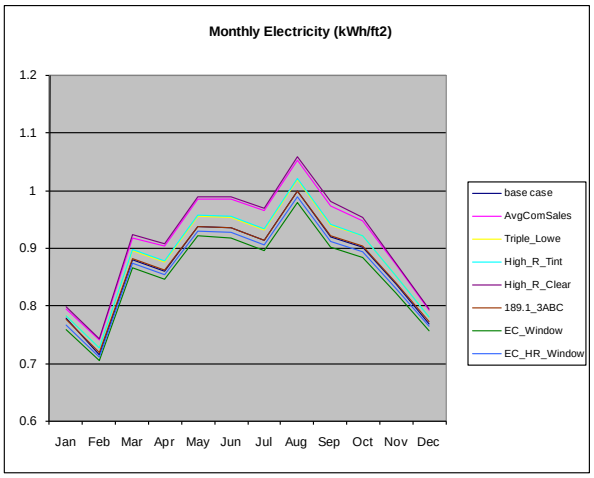


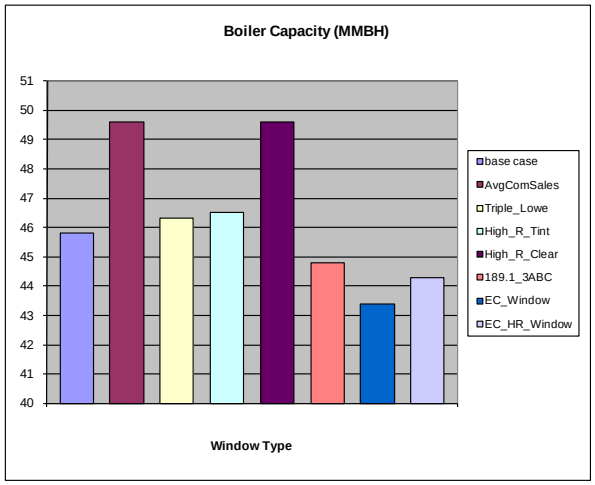





End Use Electricity kWh/ft2
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
950
900
850
800
750
700
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.2
1.1
1
0.9
0.8
0.7
0.6
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
51
50
49
48
47
46
45
44
43
42
41
40
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

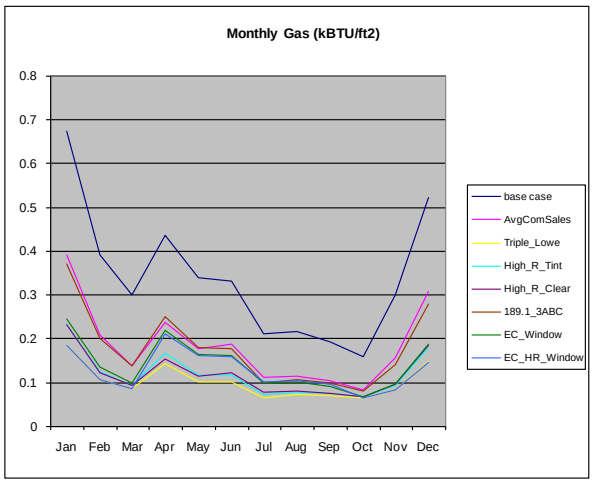
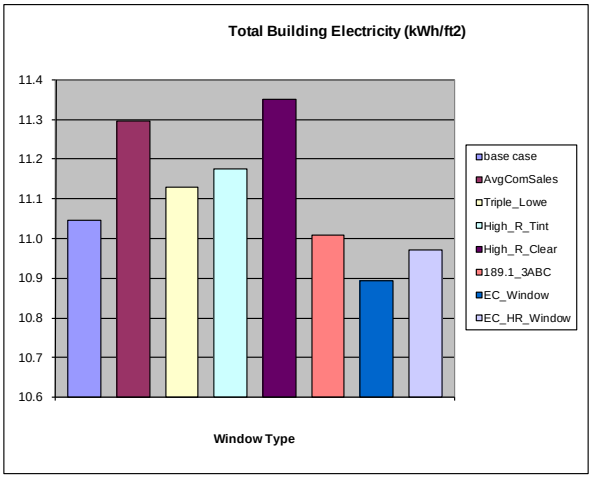
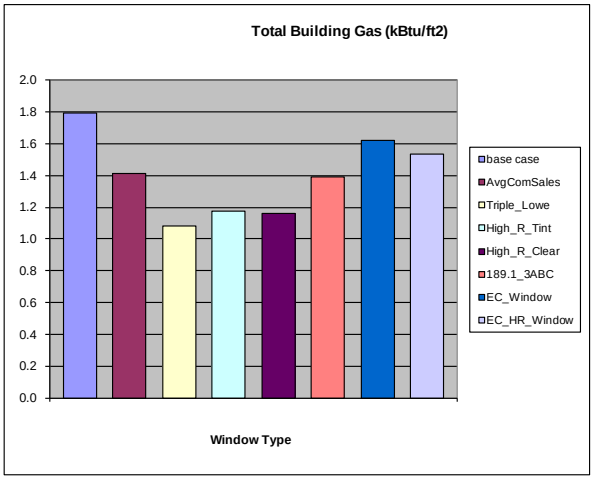
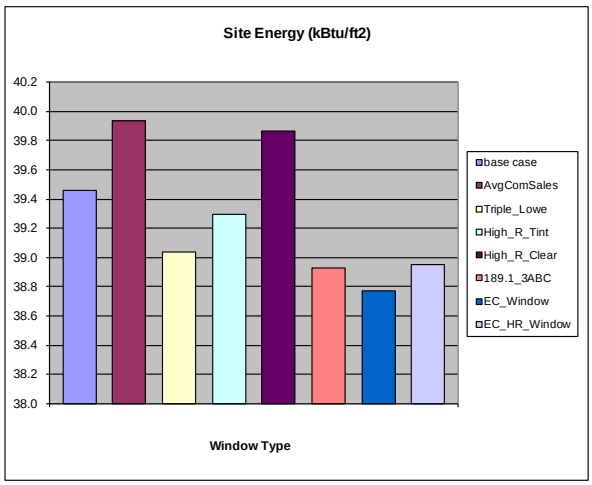
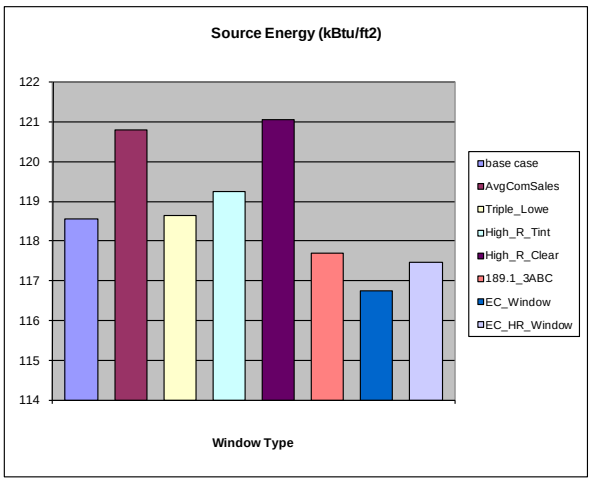

Monthly Gas (kBTU/ft2)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

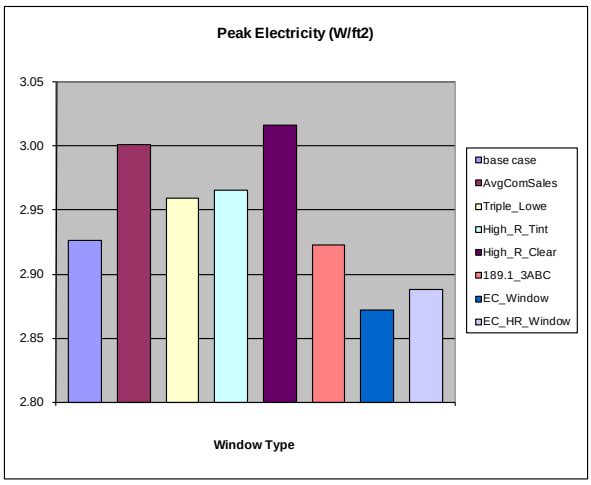
Figure 16 - For San Francisco – Shades always on, no daylighting controls

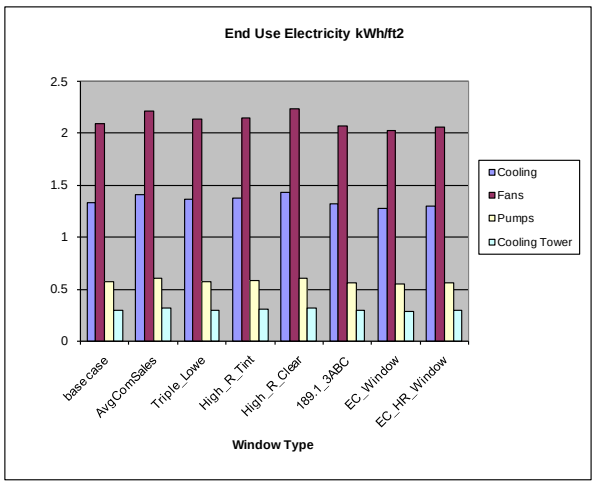


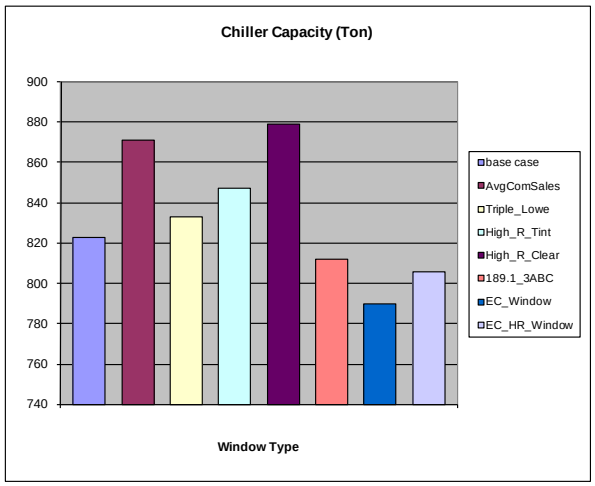


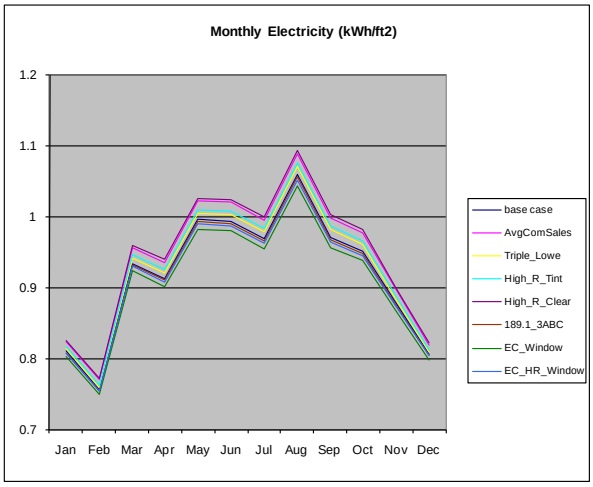


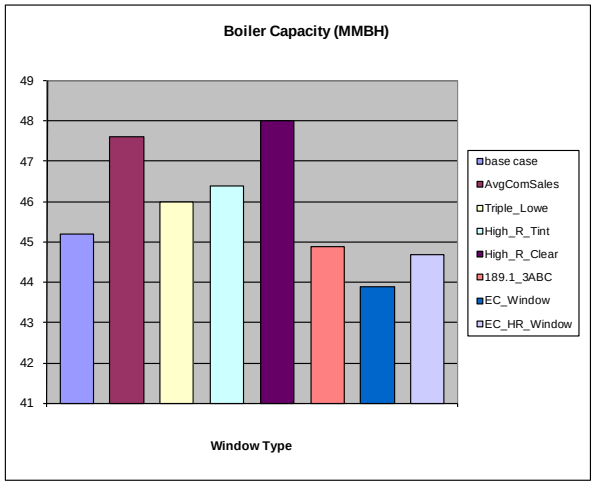





End Use Electricity kWh/ft2
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
900
880
860
840
820
800
780
760
740
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.2
1.1
1
0.9
0.8
0.7
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
49
48
47
46
45
44
43
42
41
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

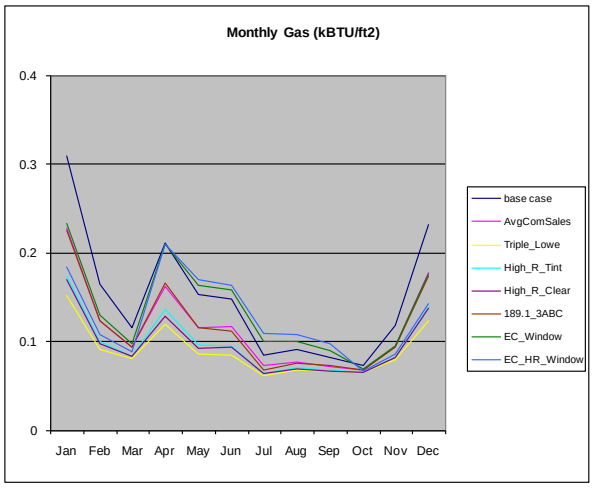
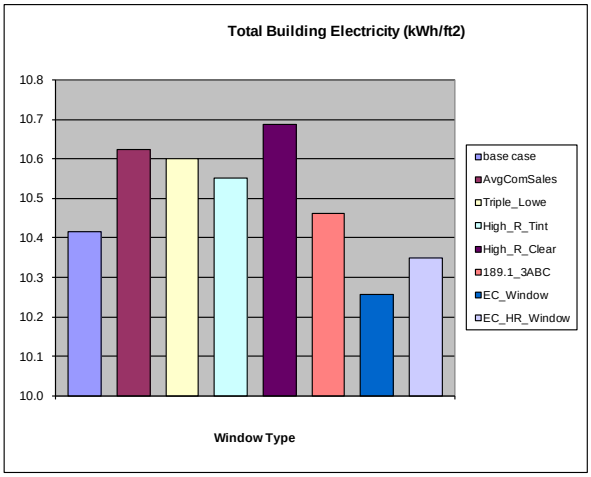
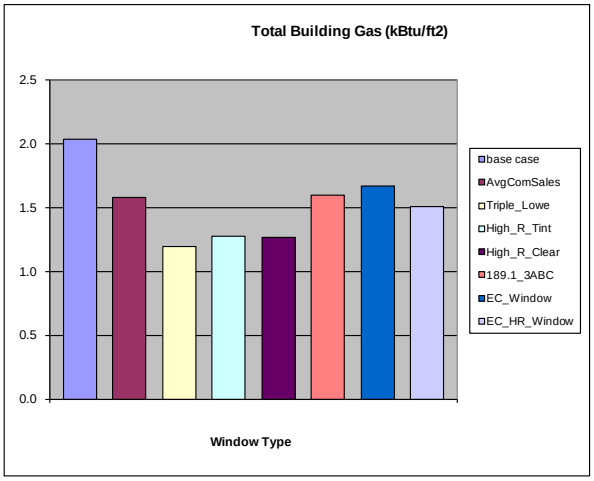
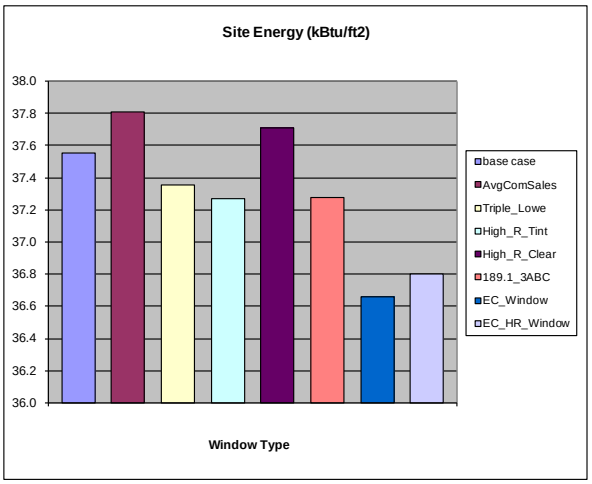
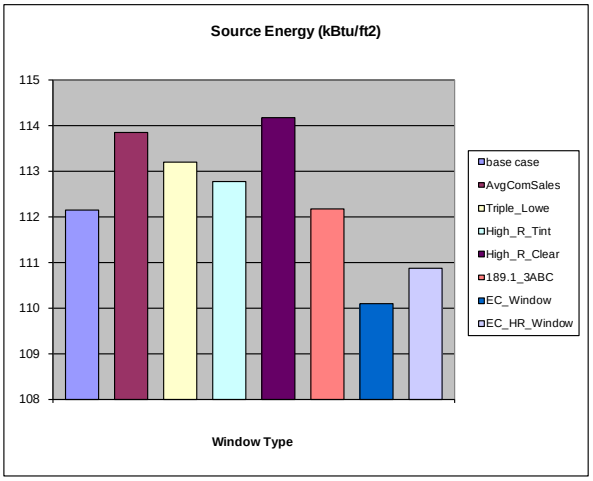

Monthly Gas (kBTU/ft2)
0.4
0.3
0.2
0.1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

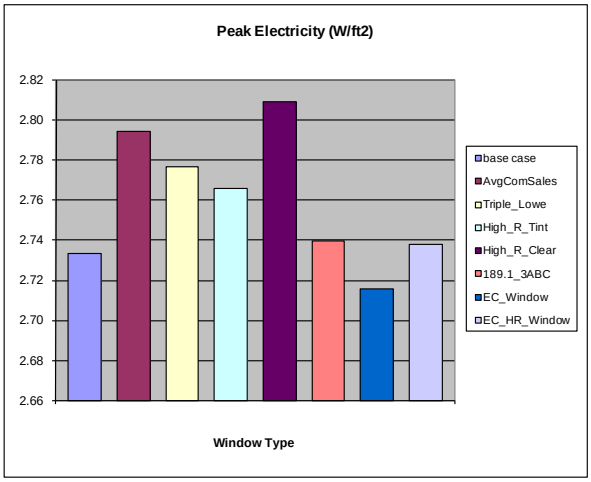
Figure 17 - For San Francisco – Shades always on, with daylighting controls

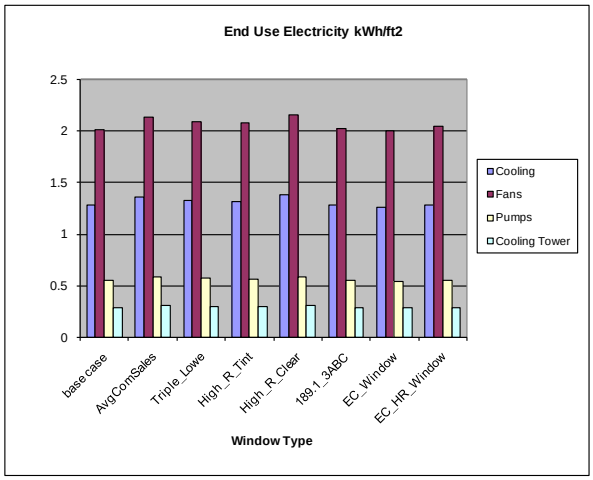


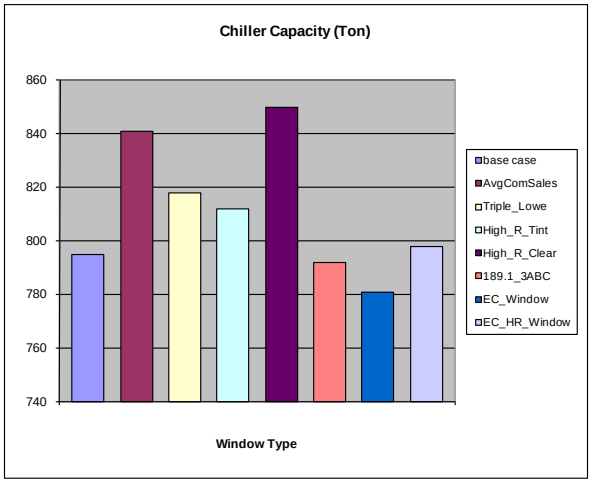


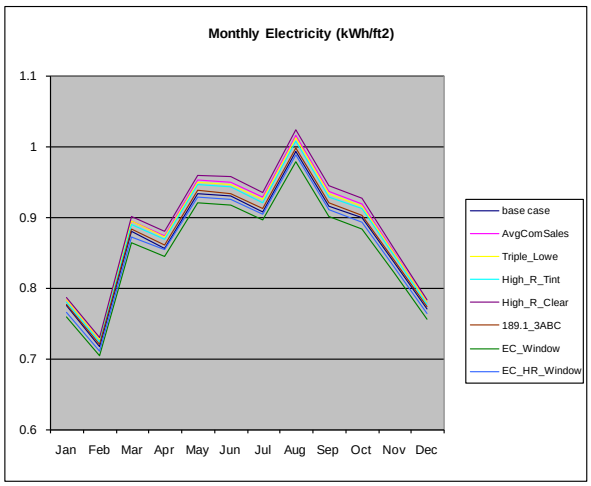


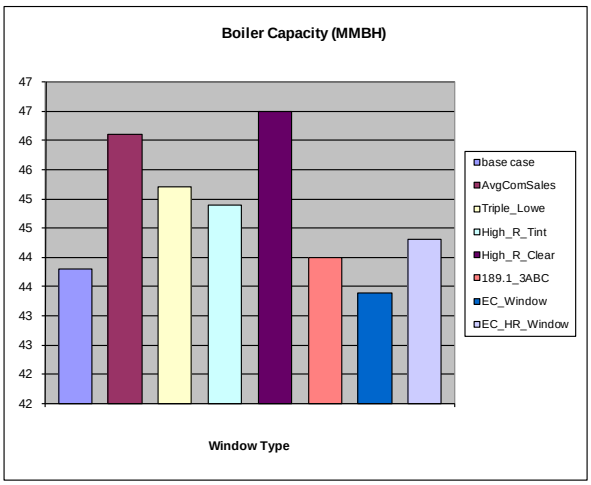





End Use Electricity kWh/ft2
2.5
2
1.5
1
0.5
0
Cooling
Fans
Pumps
Cooling Tower
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Chiller Capacity (Ton)
860
840
820
800
780
760
740
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Monthly Electricity (kWh/ft2)
1.1
1
0.9
0.8
0.7
0.6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
47
47
46
46
45
45
44
44
43
43
42
42
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type

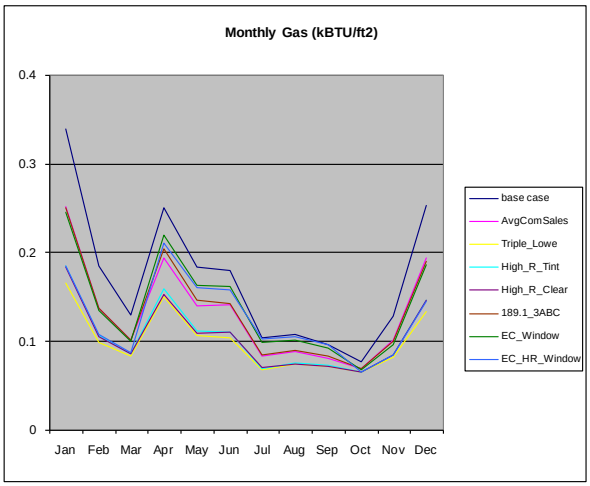
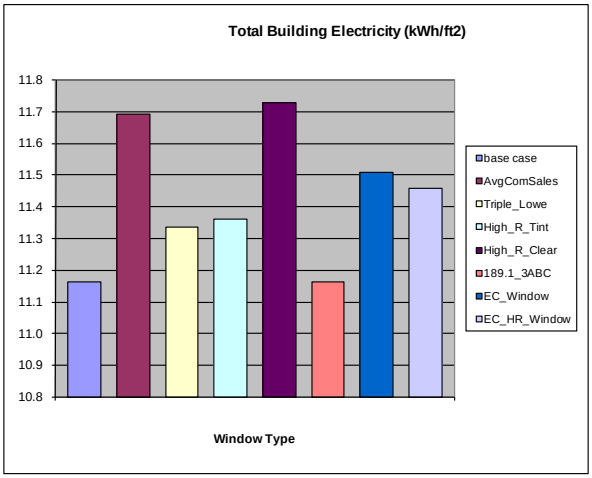
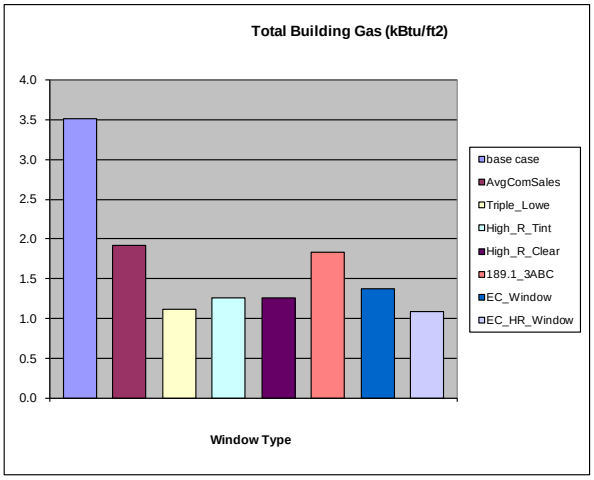
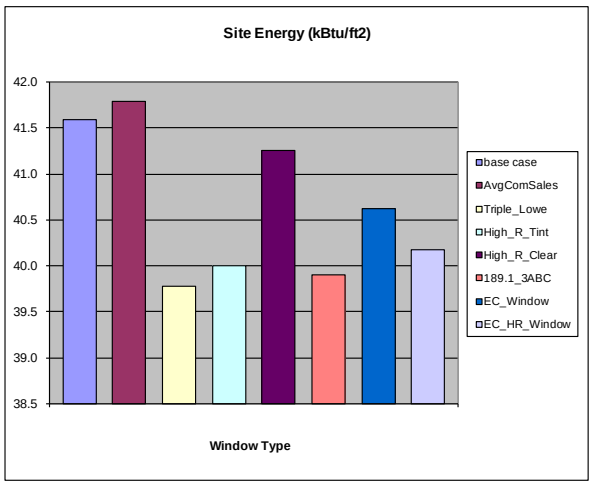
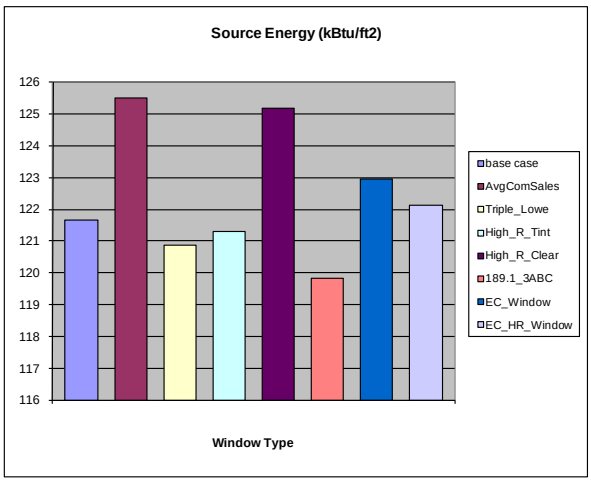

Monthly Gas (kBTU/ft2)
0.4
0.3
0.2
0.1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

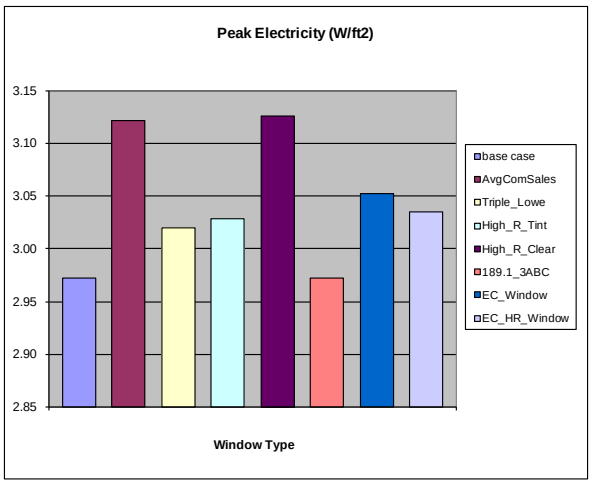
Figure 18 - For San Francisco – Shades always off, no daylighting controls

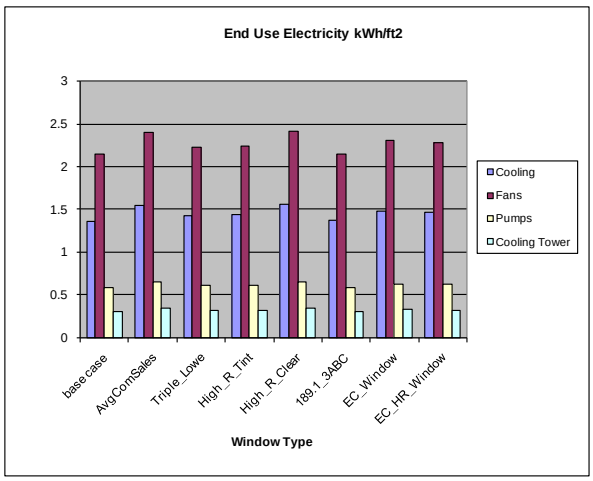


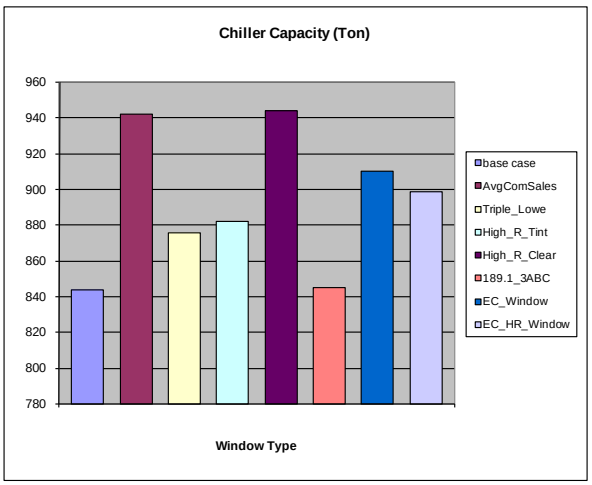


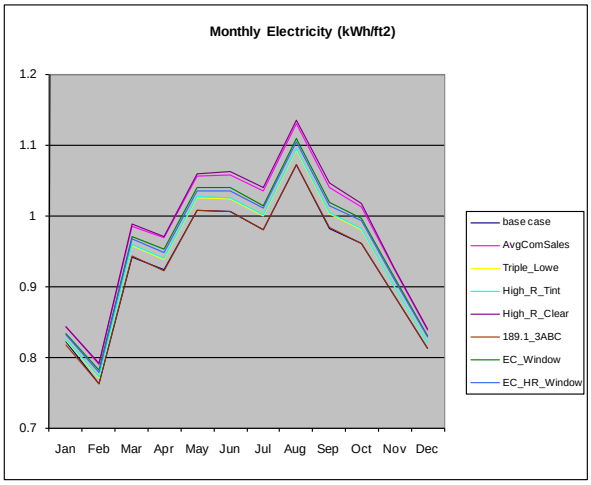


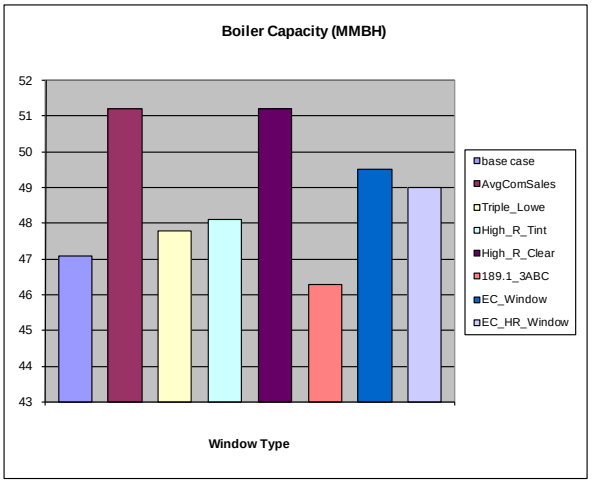


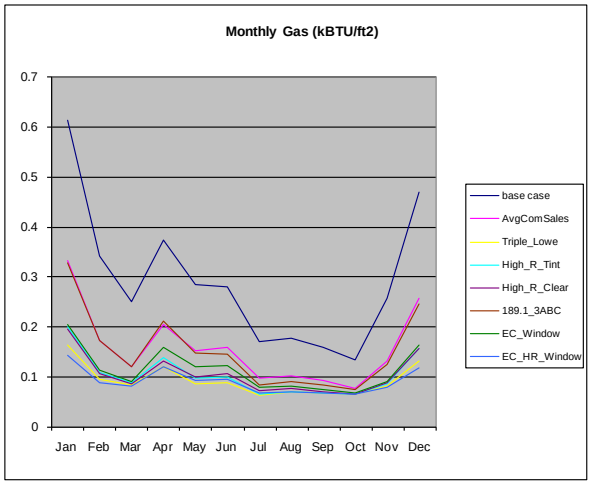



End Use Electricity kWh/ft2
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Cooling
Fans
Pumps
Cooling Tower
Window Type


Chiller Capacity (Ton)
960
940
920
900
880
860
840
820
800
780
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Monthly Electricity (kWh/ft2)
1.2
1.1
1
0.9
0.8
0.7
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
52
51
50
49
48
47
46
45
44
43
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Monthly Gas (kBTU/ft2)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

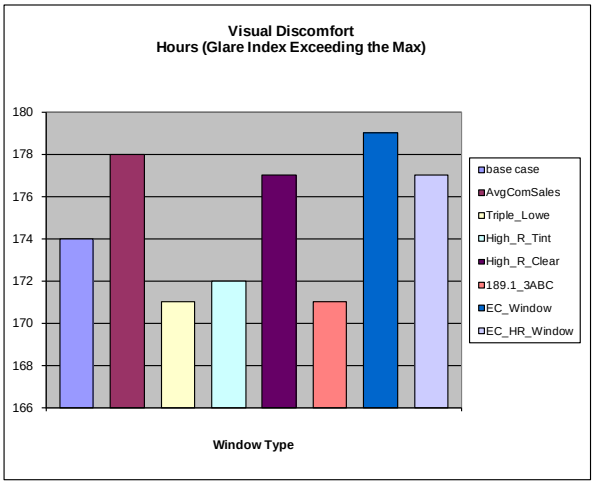
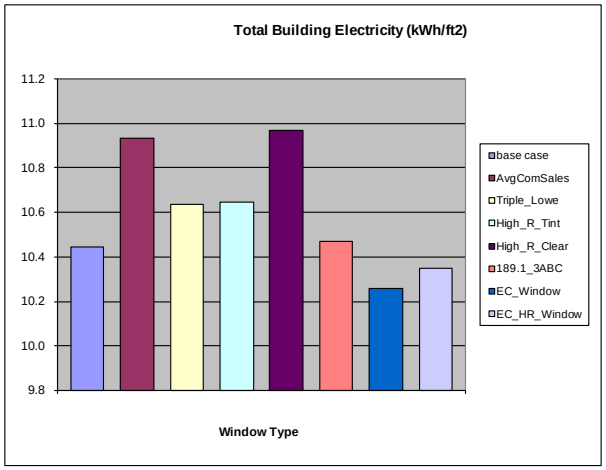
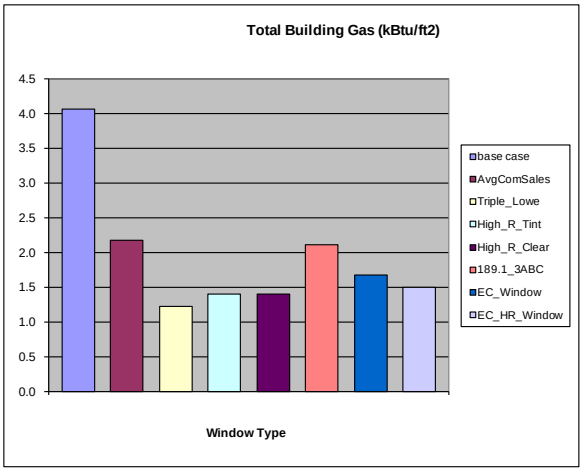
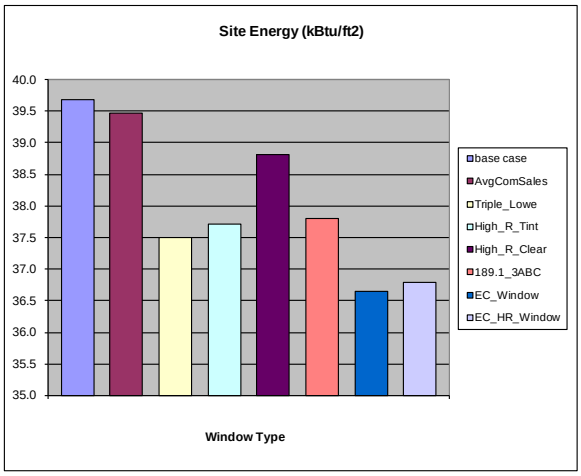
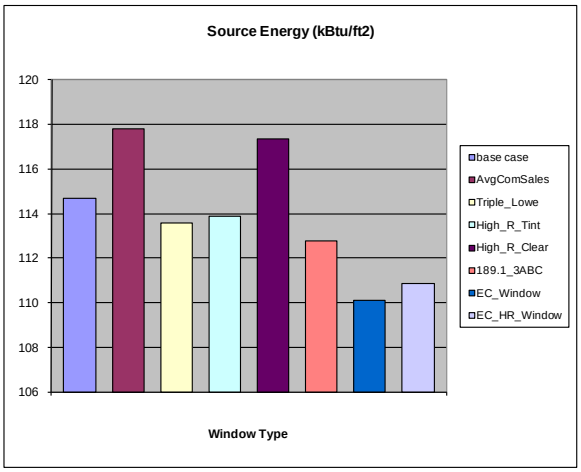

Visual Discomfort
Hours (Glare Index Exceeding the Max)
180
178
176
174
172
170
168
166
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type

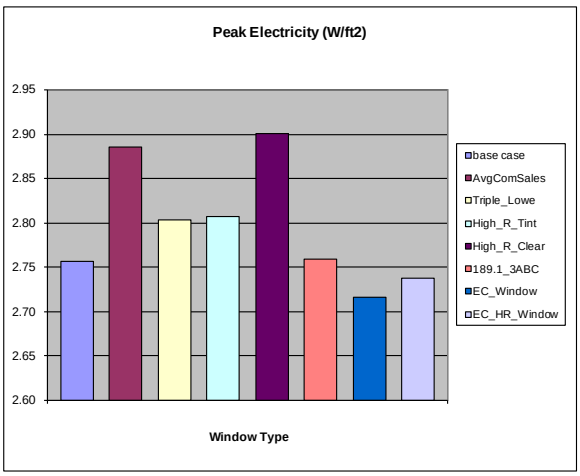
Figure 19 - For San Francisco – Shades always off, with daylighting controls

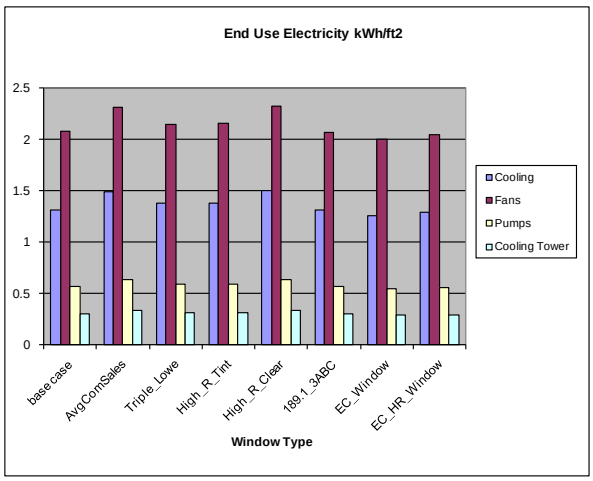


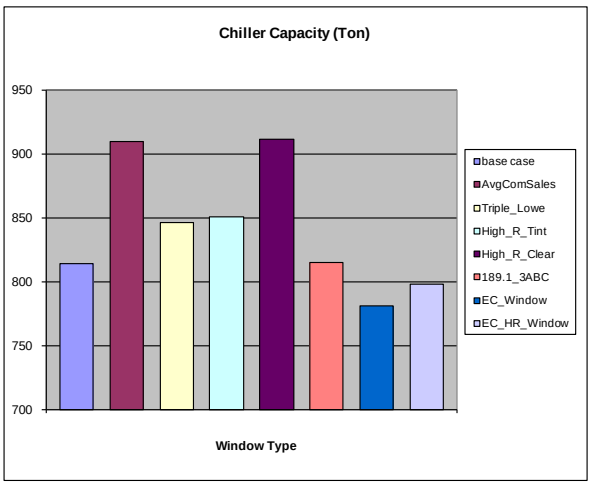


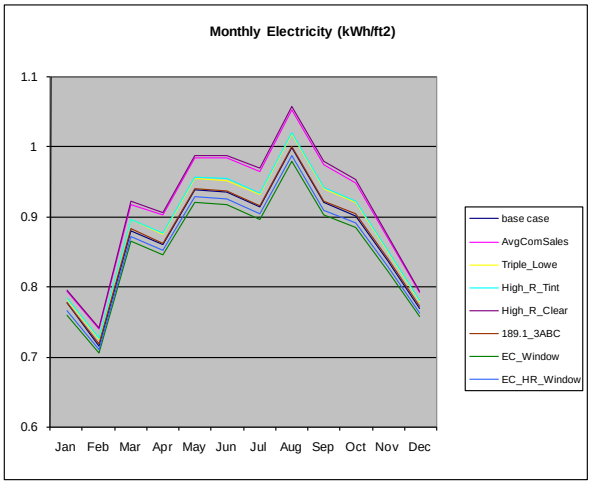


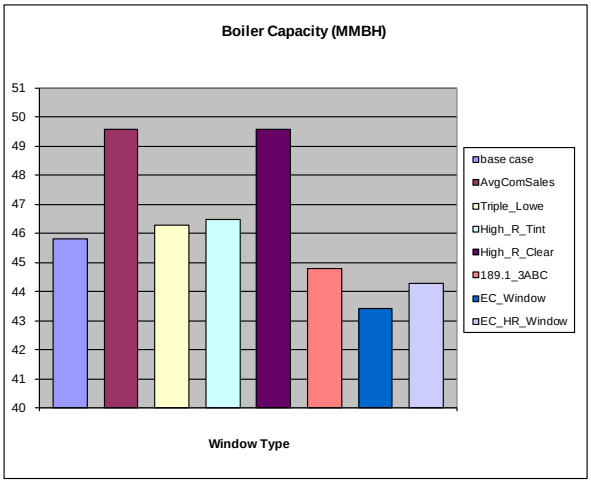


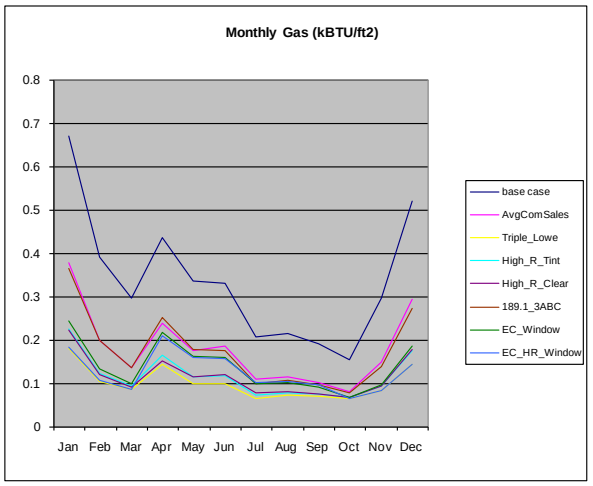



End Use Electricity kWh/ft2
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
950
900
850
800
750
700
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.1
1
0.9
0.8
0.7
0.6
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
51
50
49
48
47
46
45
44
43
42
41
40
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Gas (kBTU/ft2)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

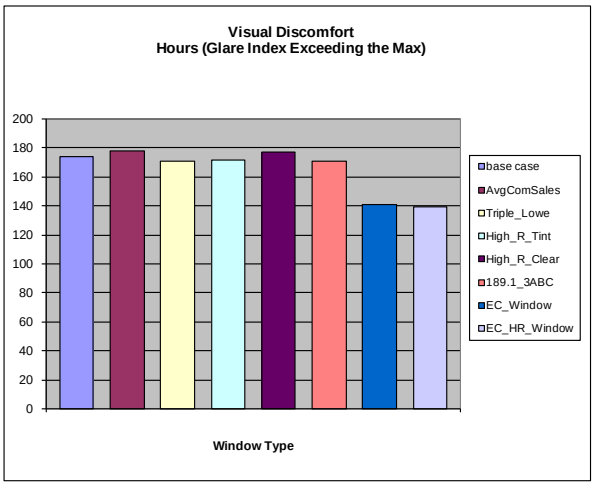
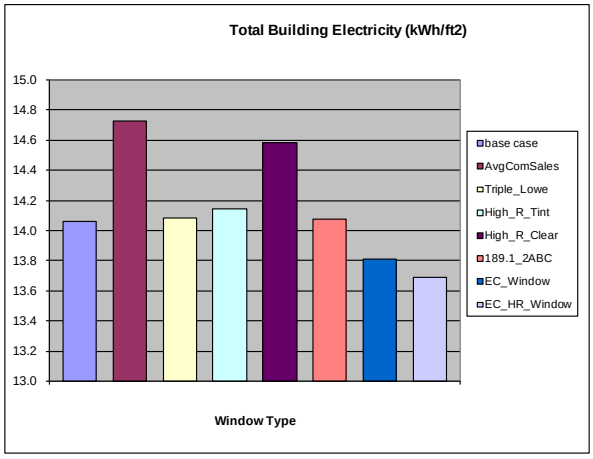
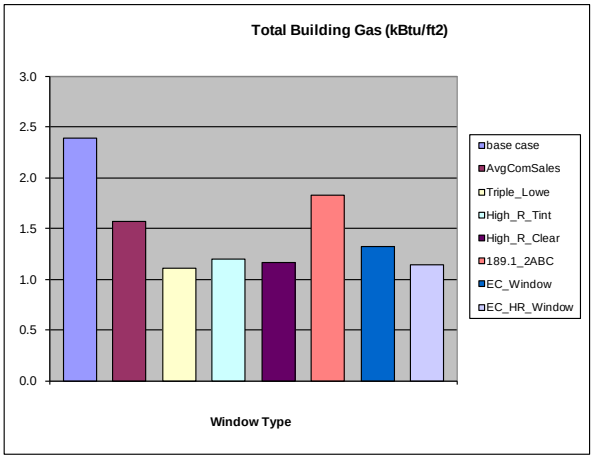
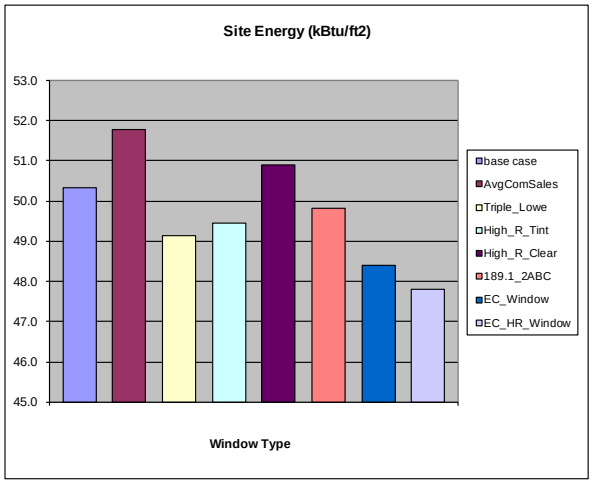
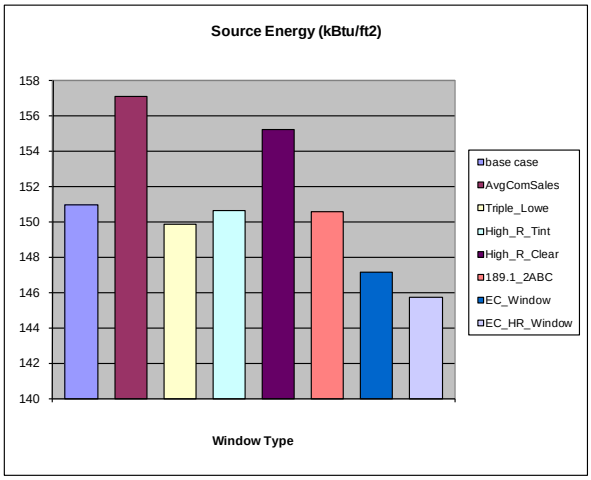

Visual Discomfort
Hours (Glare Index Exceeding the Max)
200
180
160
140
120
100
80
60
40
20
0
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

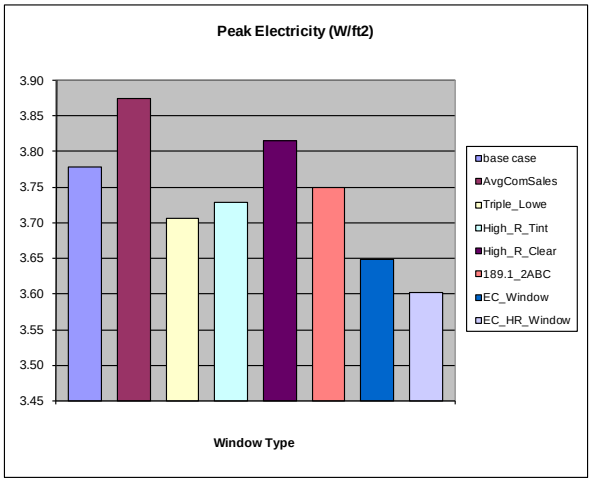
Figure 20 - For Phoenix – Shades on if high glare, no daylighting controls

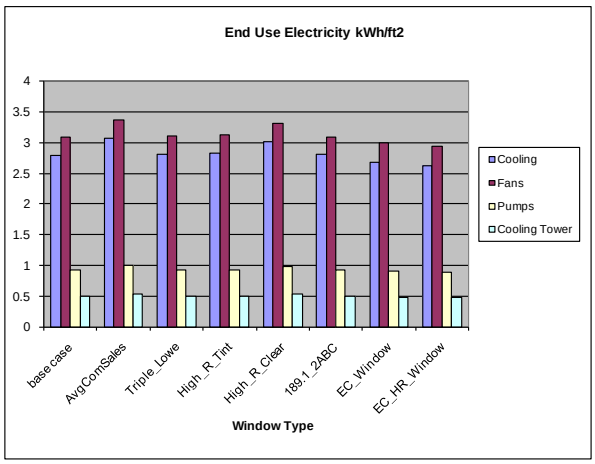


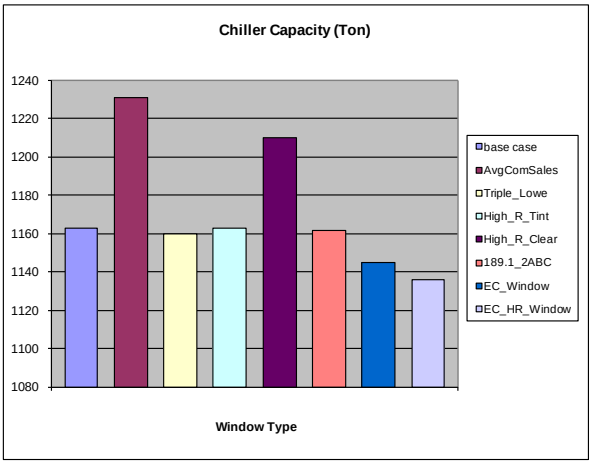


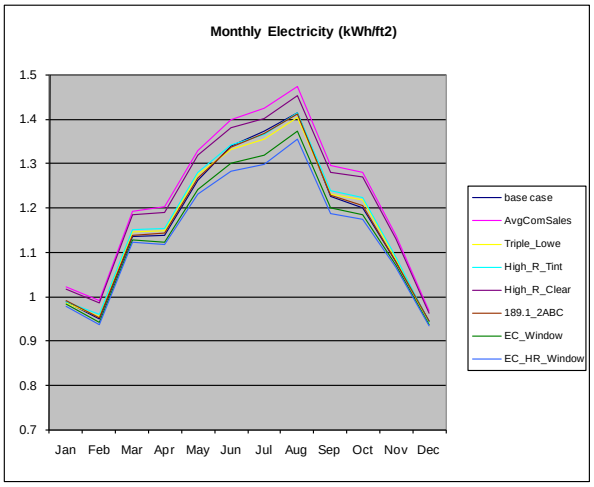


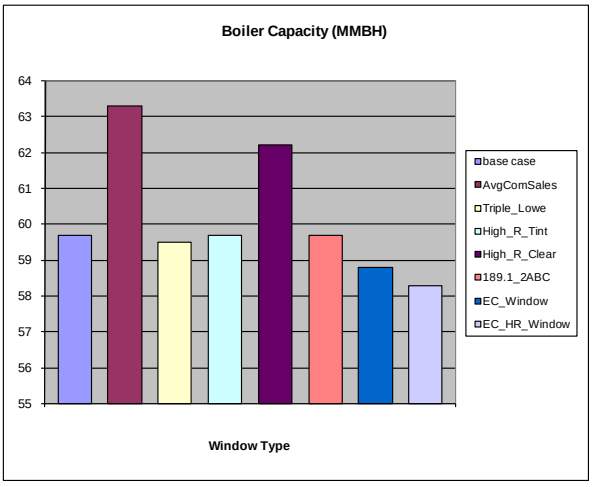





End Use Electricity kWh/ft2
4
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_2ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1240
1220
1200
1180
1160
1140
1120
1100
1080
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_2ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_2ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
64
63
62
61
60
59
58
57
56
55
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_2ABC
EC_Window
EC_HR_Window

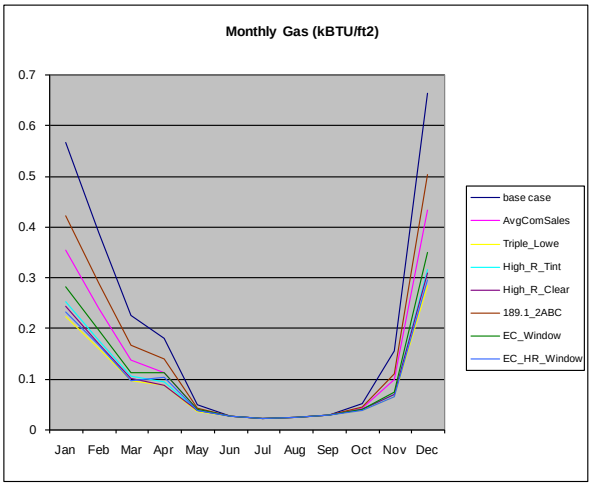
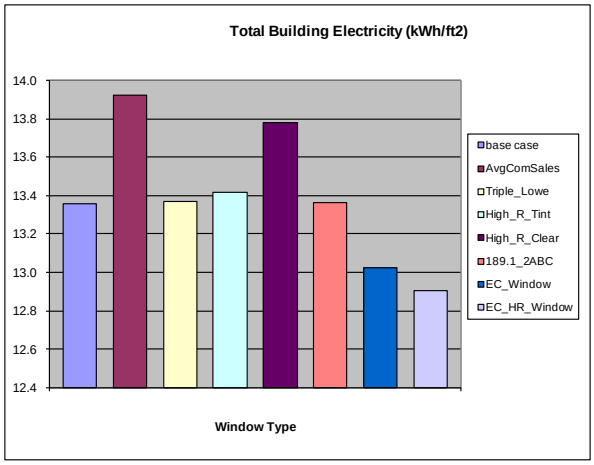
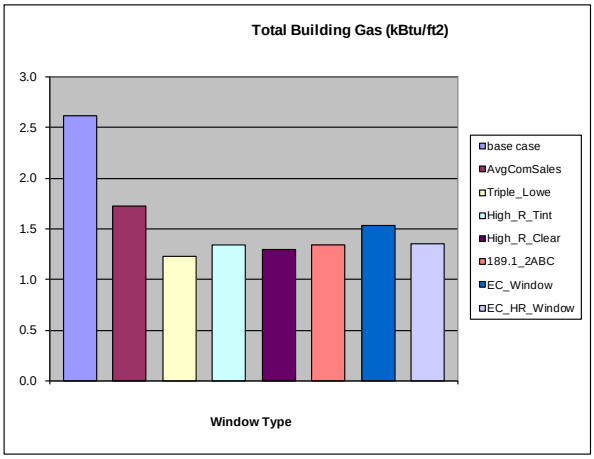
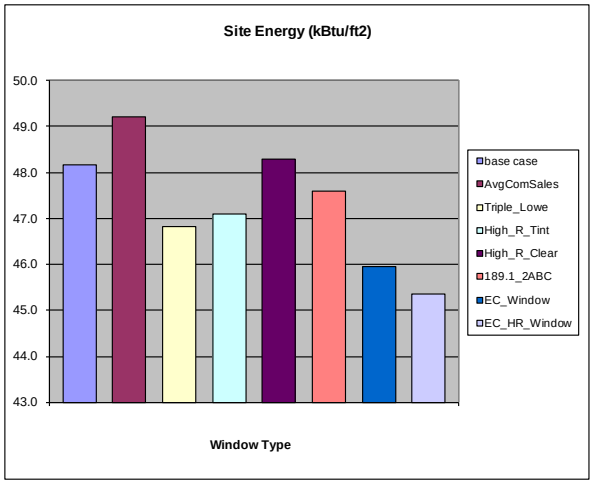
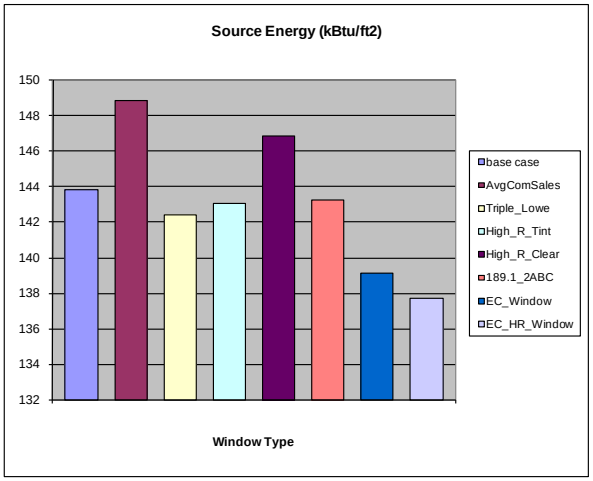

Monthly Gas (kBTU/ft2)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_2ABC
EC_Window
EC_HR_Window

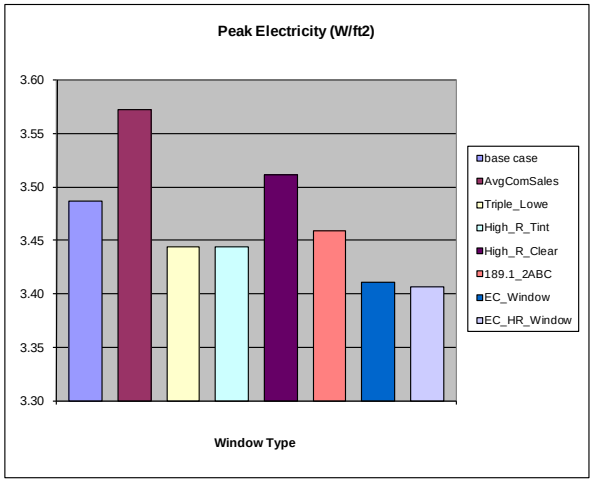
Figure 21 - For Phoenix – Shades on if high glare, with daylighting controls

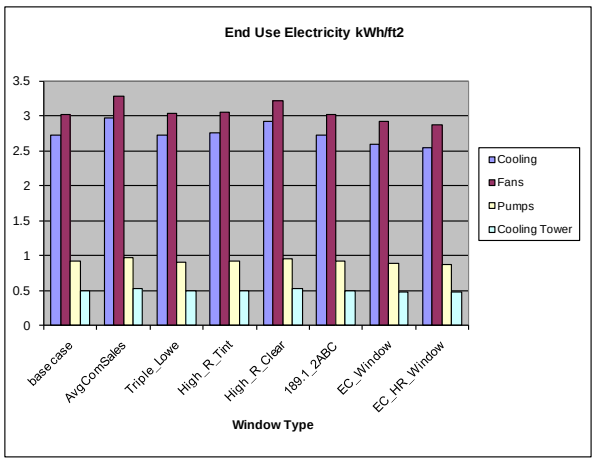


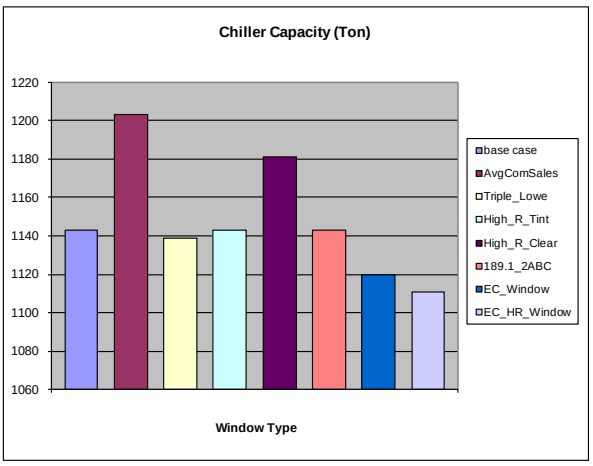


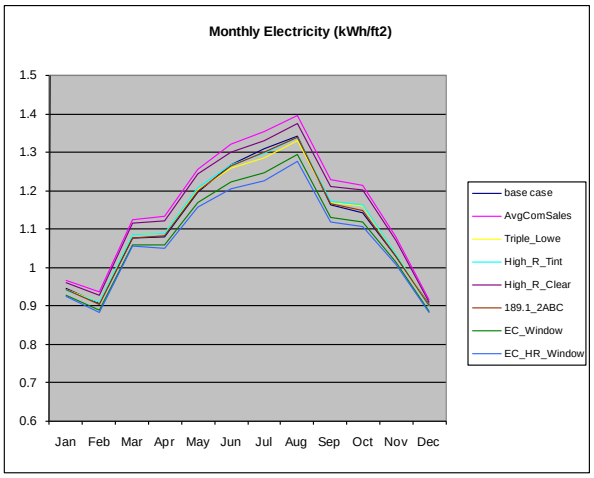


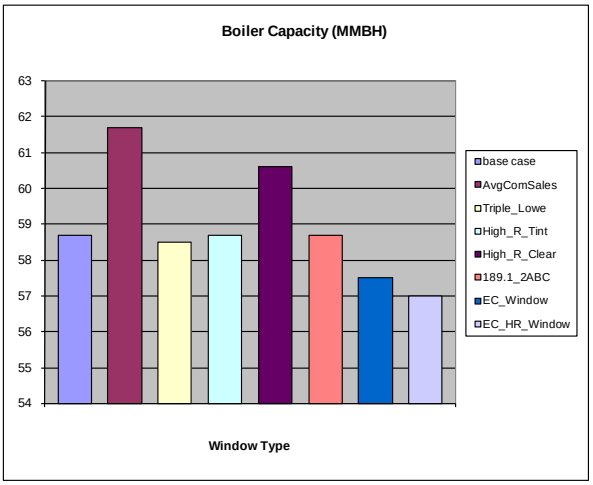





End Use Electricity kWh/ft2
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_2ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1220
1200
1180
1160
1140
1120
1100
1080
1060
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_2ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_2ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
63
62
61
60
59
58
57
56
55
54
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_2ABC
EC_Window
EC_HR_Window

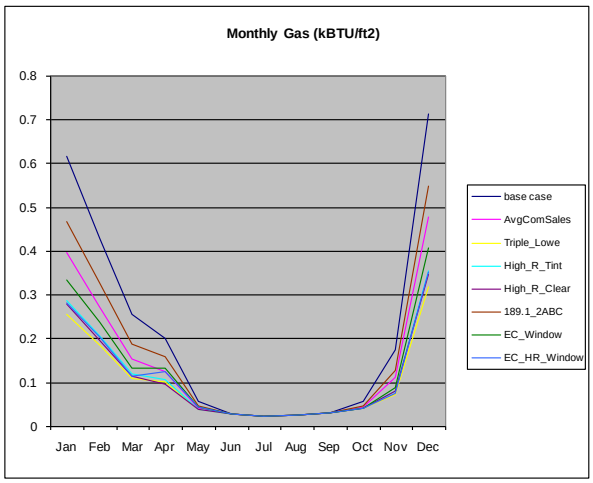
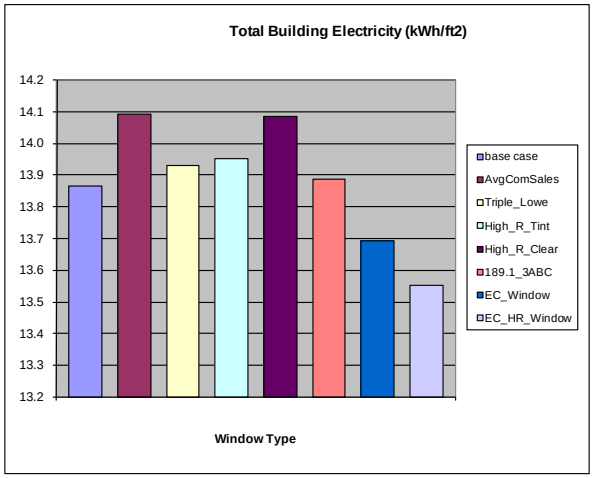
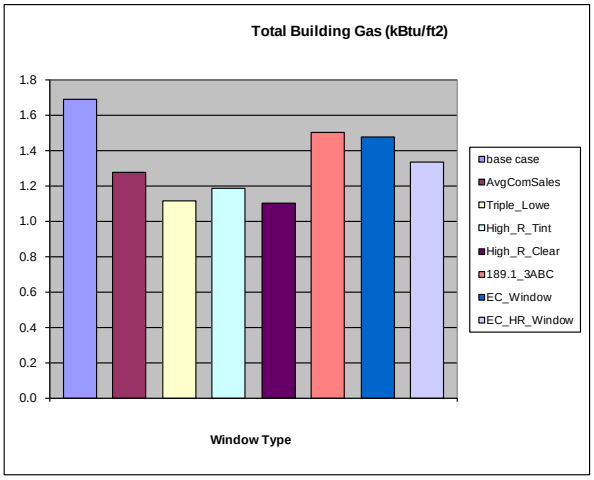
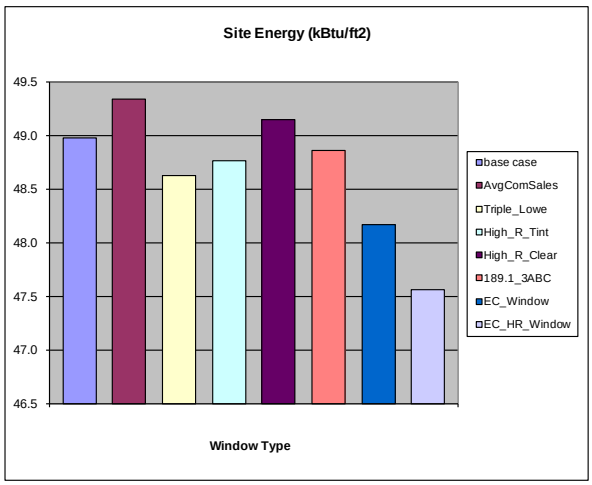
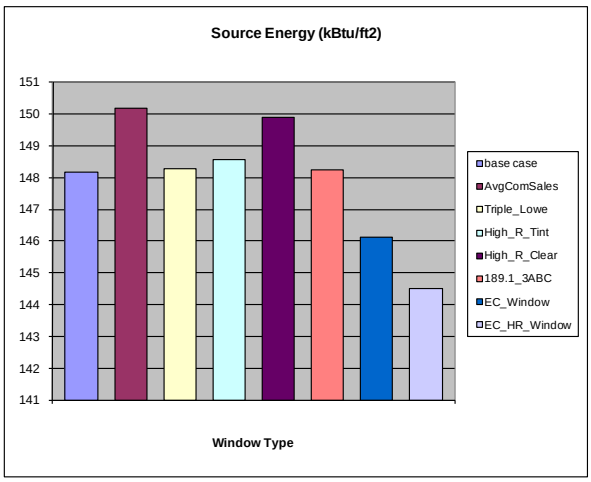

Monthly Gas (kBTU/ft2)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_2ABC
EC_Window
EC_HR_Window

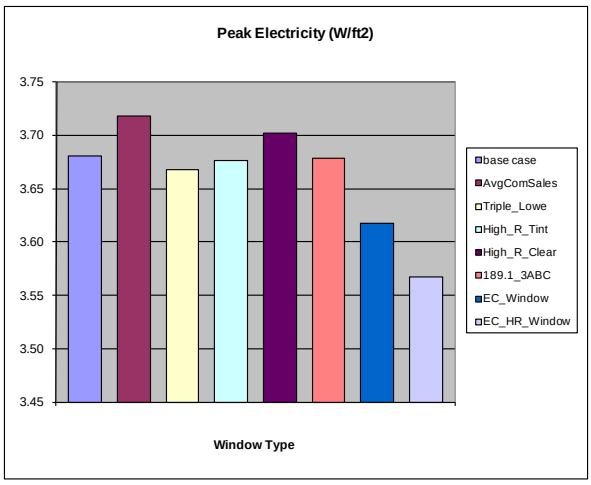
Figure 22 - For Phoenix – Shades always on, no daylighting controls

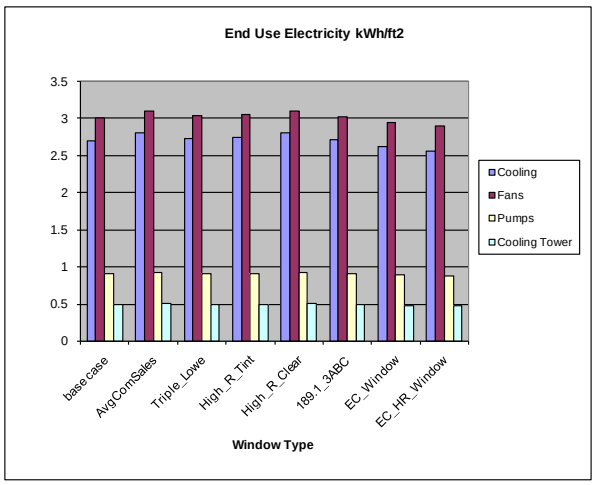


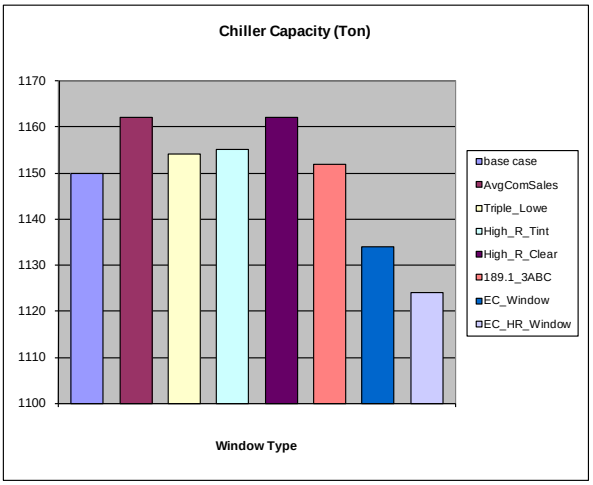


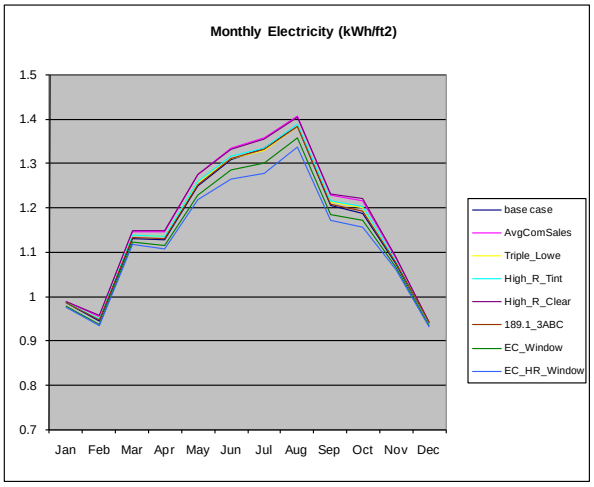


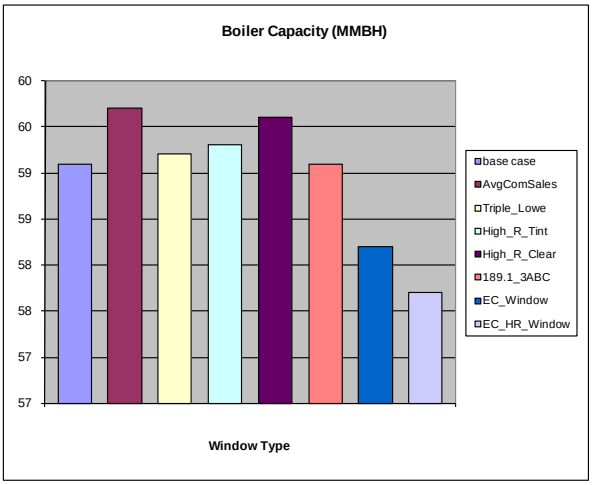





End Use Electricity kWh/ft2
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1170
1160
1150
1140
1130
1120
1110
1100
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
60
60
59
59
58
58
57
57
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

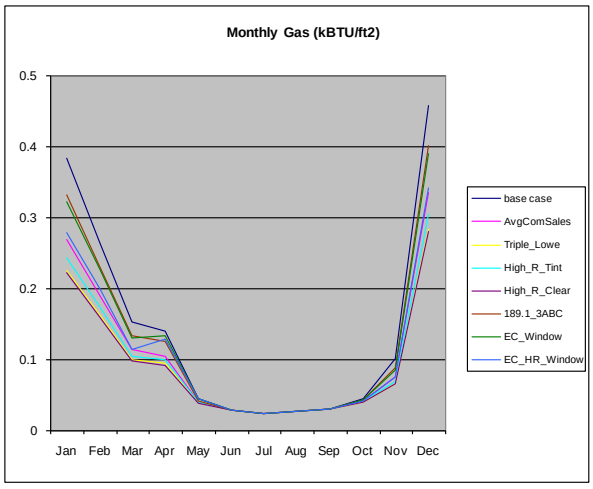
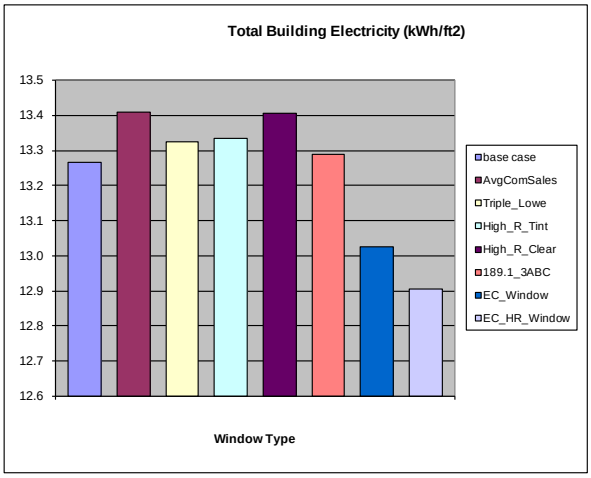
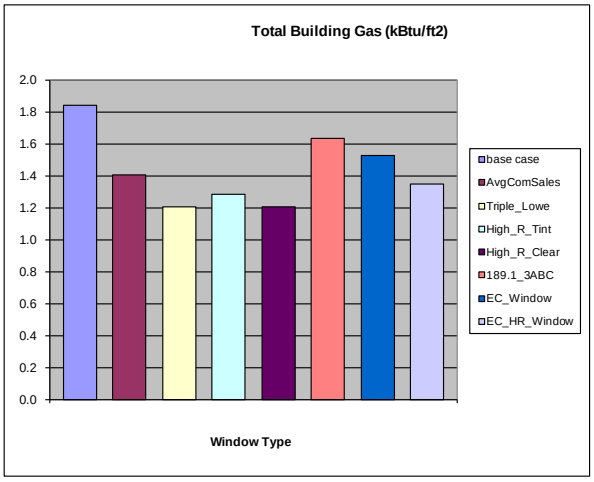
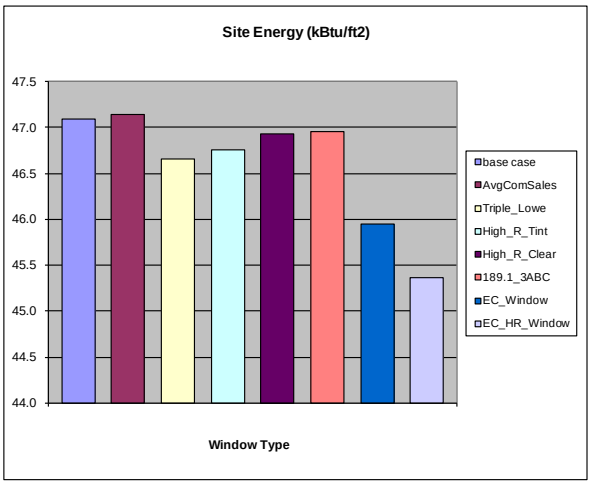
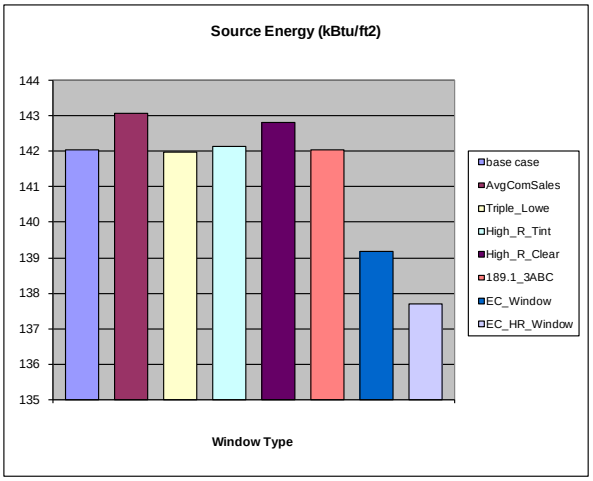

Monthly Gas (kBTU/ft2)
0.5
0.4
0.3
0.2
0.1
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

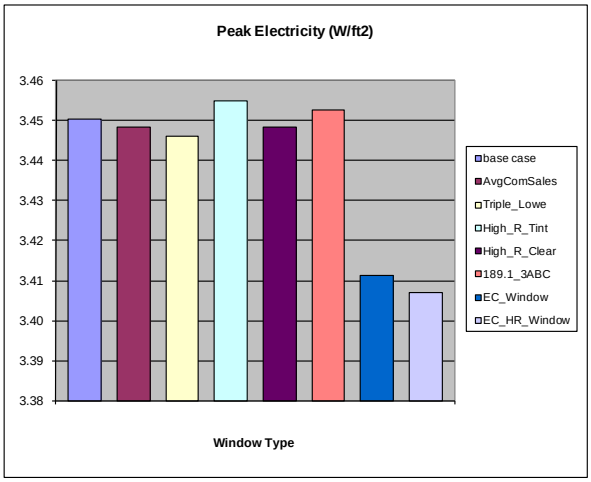
Figure 23 - For Phoenix – Shades always on, with daylighting controls

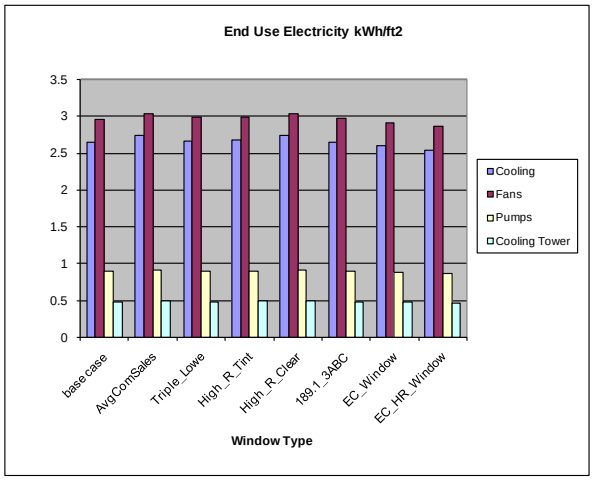


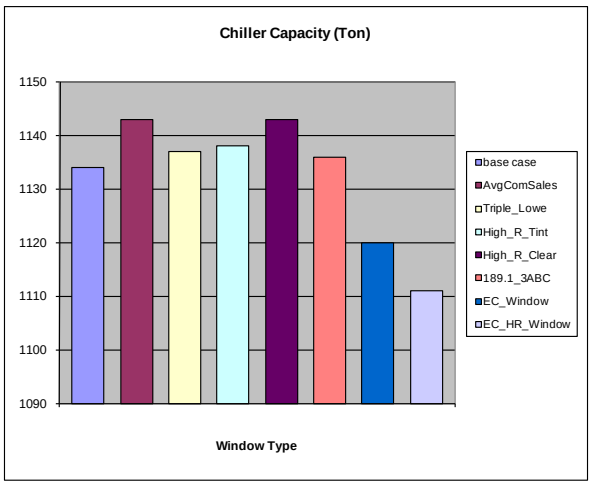


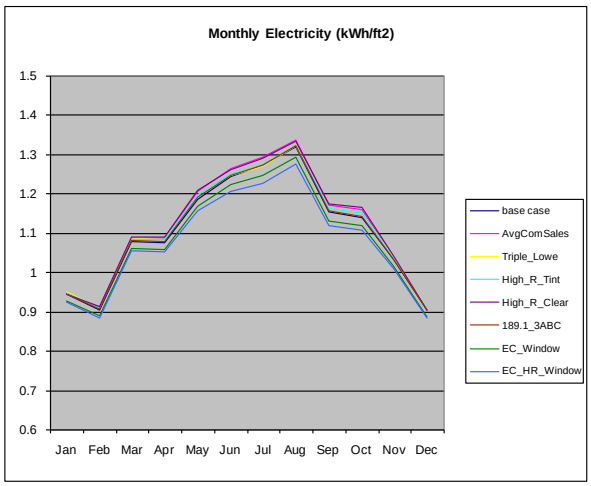


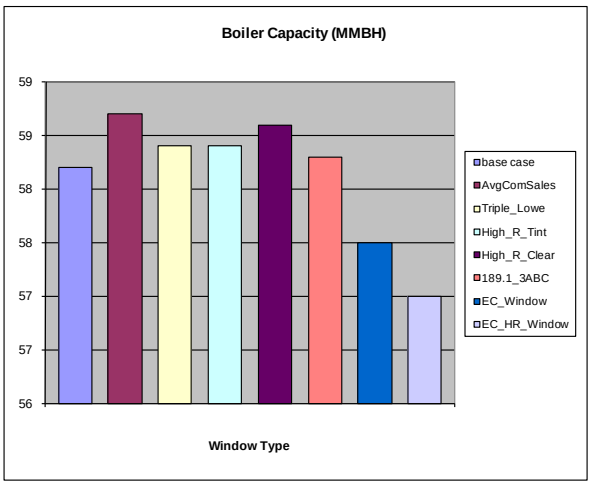





End Use Electricity kWh/ft2
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1150
1140
1130
1120
1110
1100
1090
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
59
59
58
58
57
57
56
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

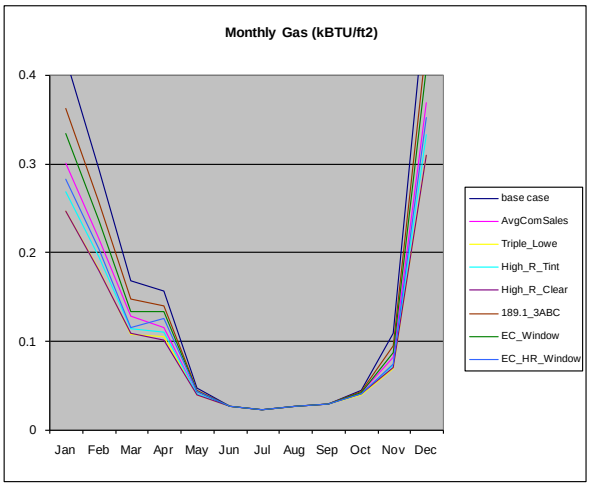
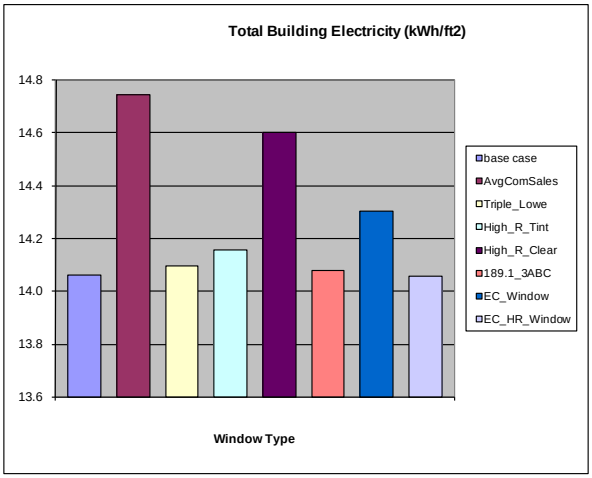
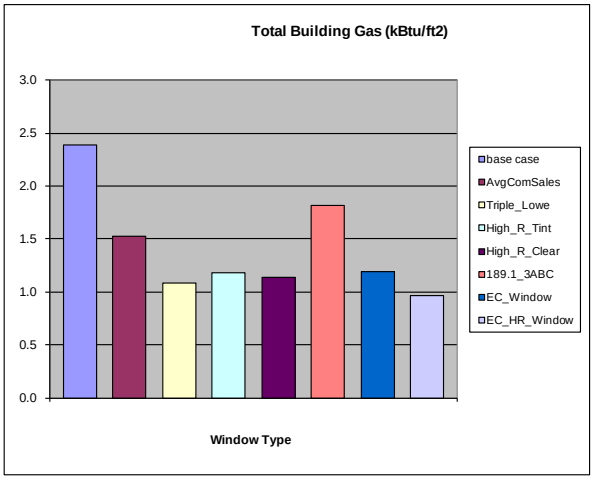
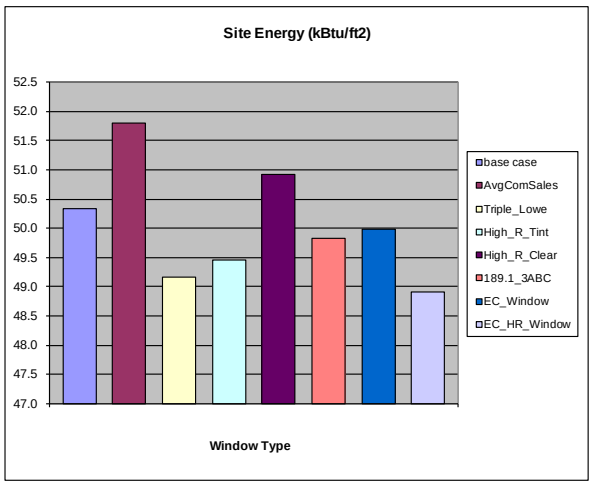
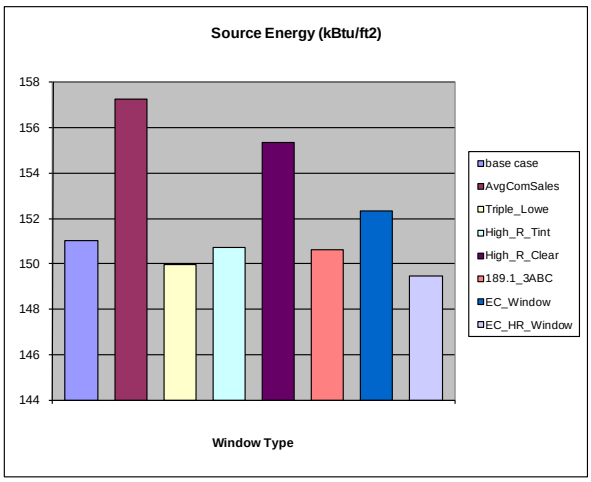

Monthly Gas (kBTU/ft2)
0.4
0.3
0.2
0.1
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

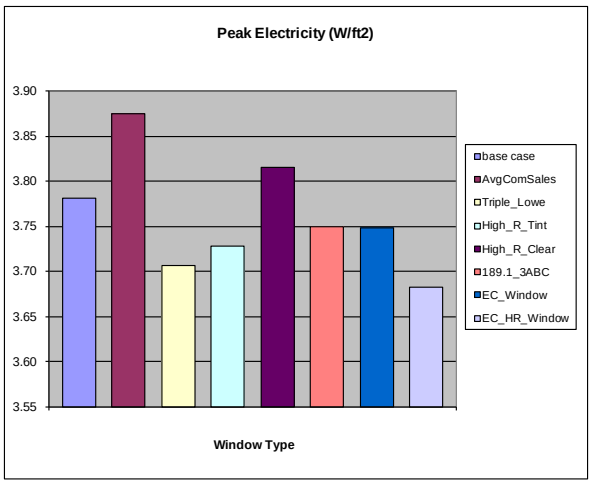
Figure 24 - For Phoenix – Shades always off, no daylighting controls

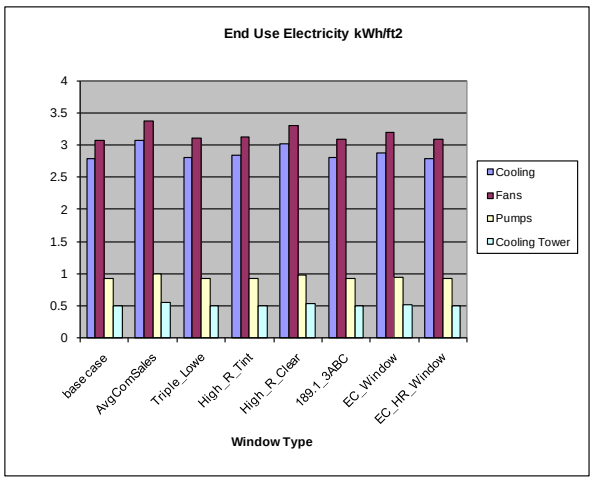


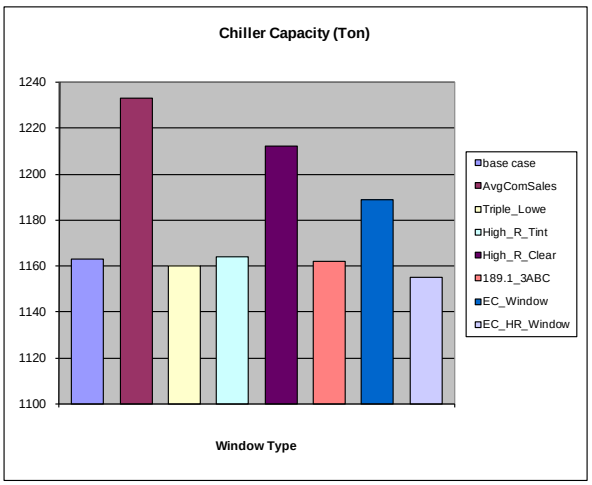


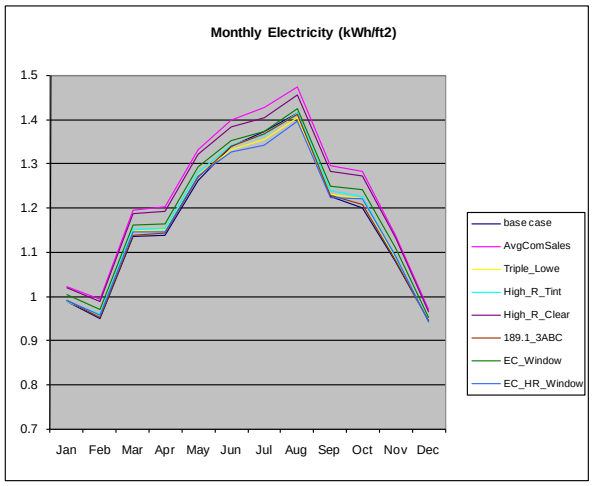


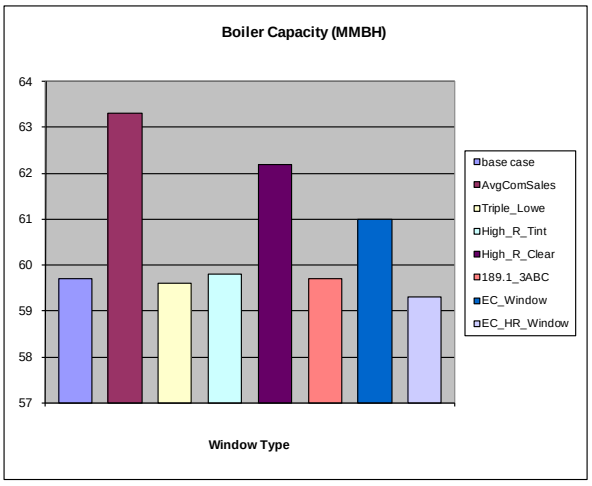


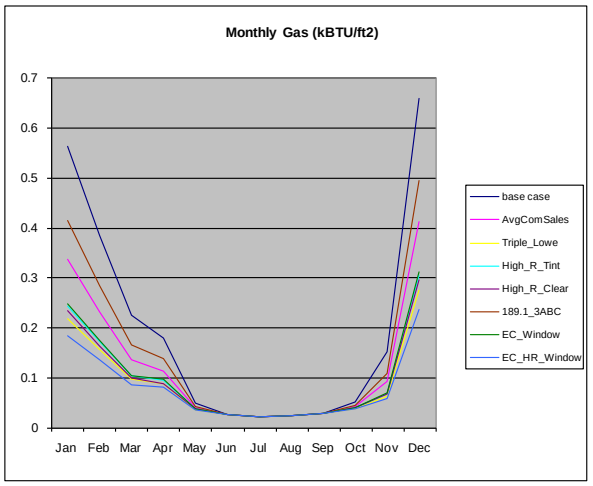



End Use Electricity kWh/ft2
4
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Cooling
Fans
Pumps
Cooling Tower
Window Type


Chiller Capacity (Ton)
1240
1220
1200
1180
1160
1140
1120
1100
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Monthly Electricity (kWh/ft2)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
64
63
62
61
60
59
58
57
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Monthly Gas (kBTU/ft2)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

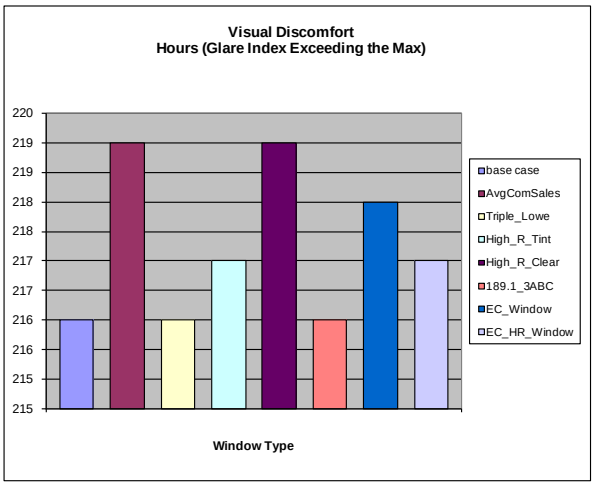
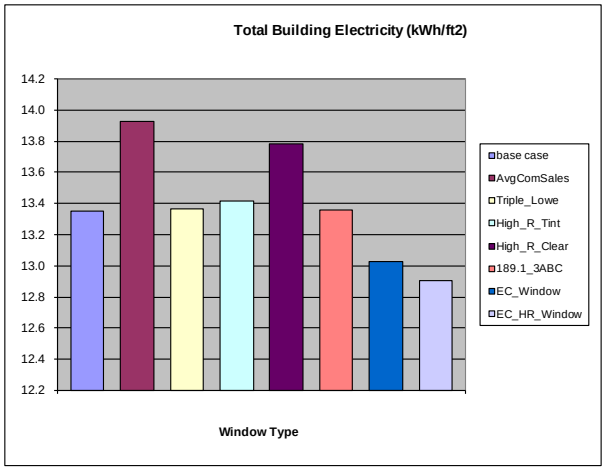
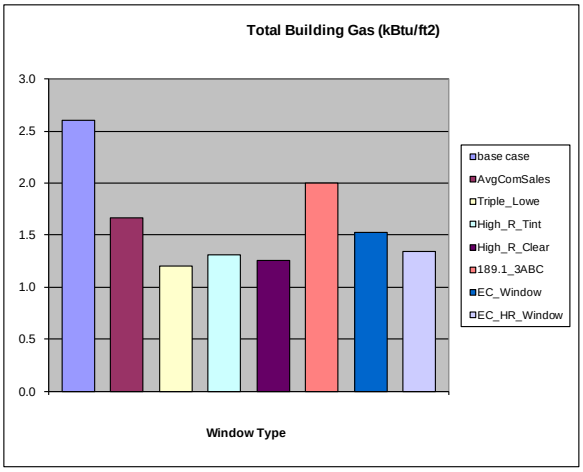
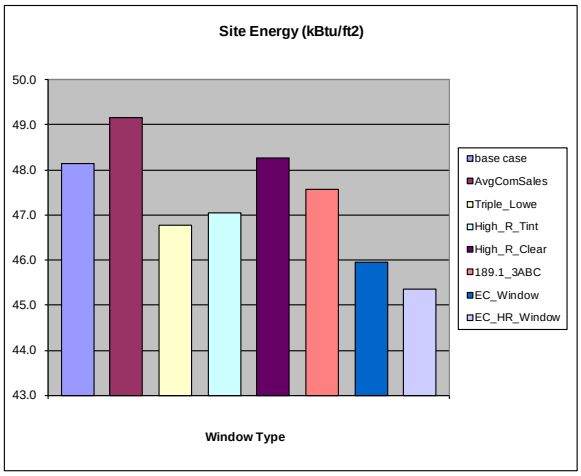
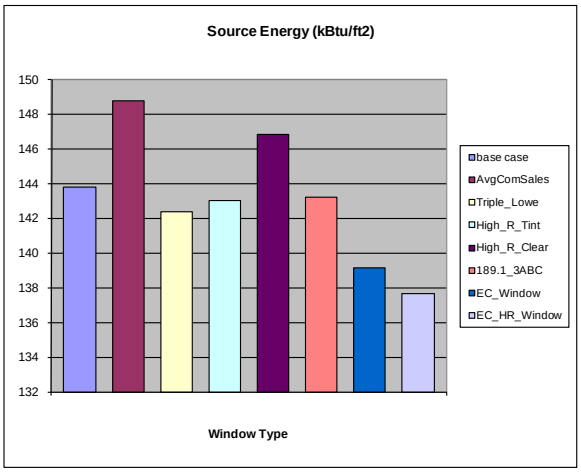

Visual Discomfort
Hours (Glare Index Exceeding the Max)
220
219
219
218
218
217
217
216
216
215
215
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type

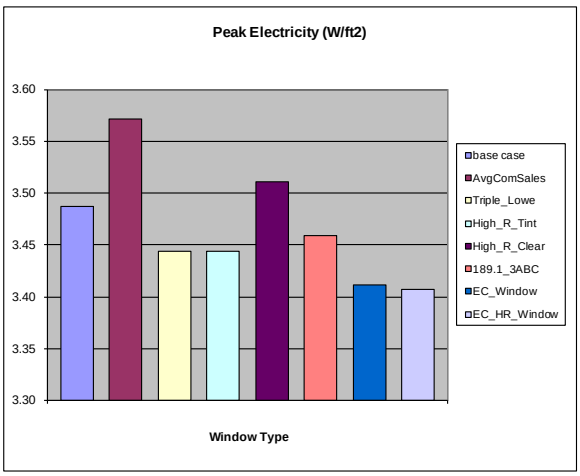
Figure 25 - For Phoenix – Shades always off, with daylighting controls

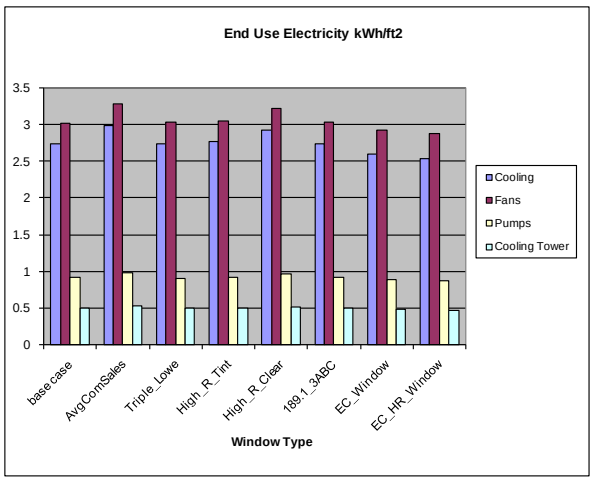


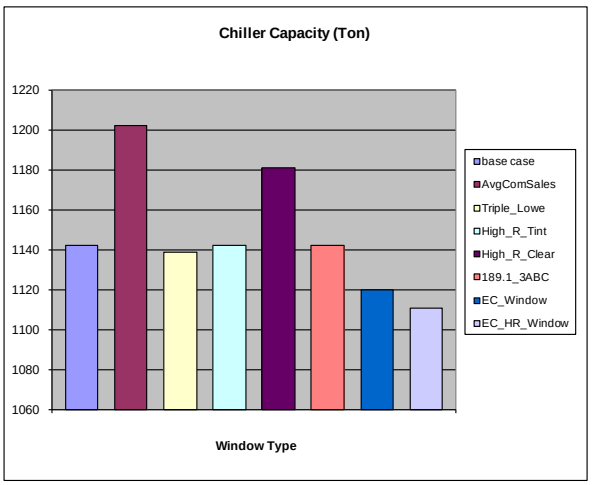


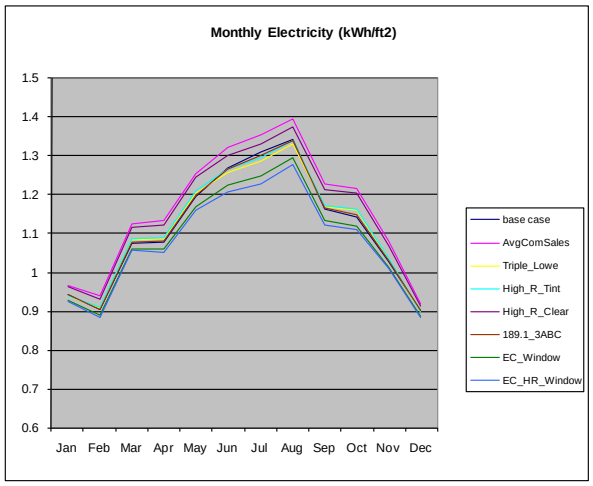


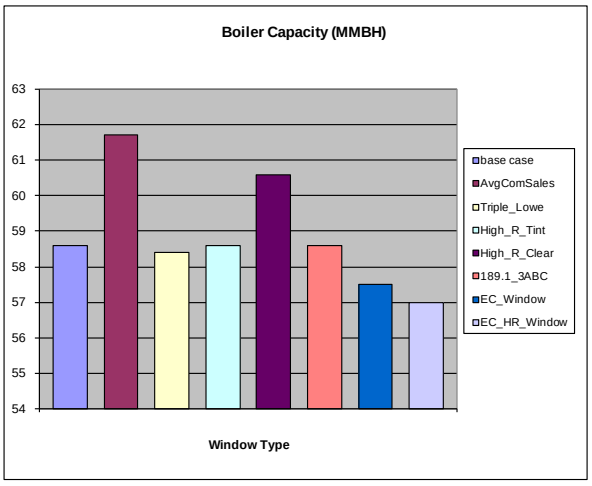


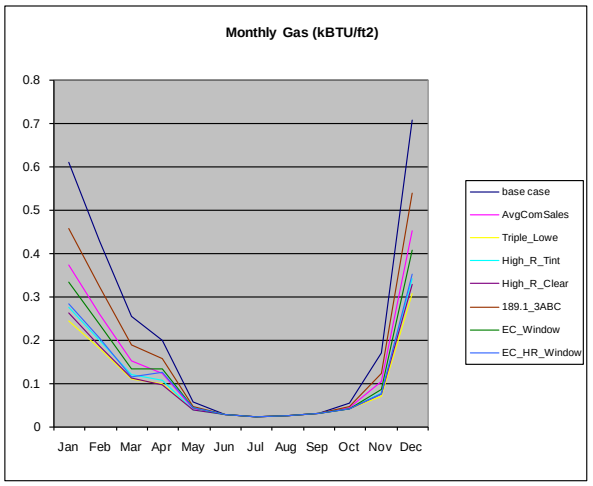



End Use Electricity kWh/ft2
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1220
1200
1180
1160
1140
1120
1100
1080
1060
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
63
62
61
60
59
58
57
56
55
54
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Gas (kBTU/ft2)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

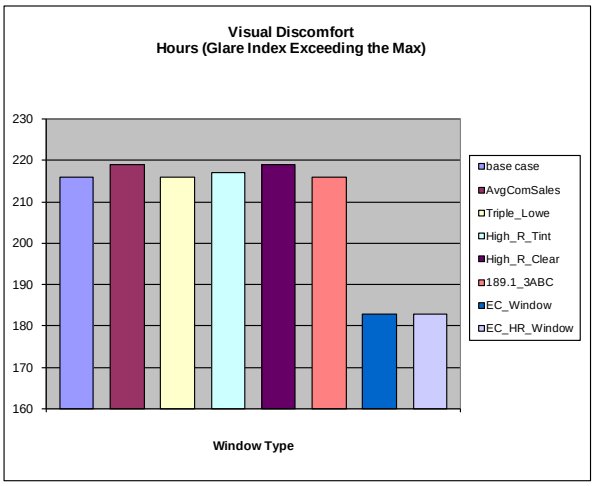
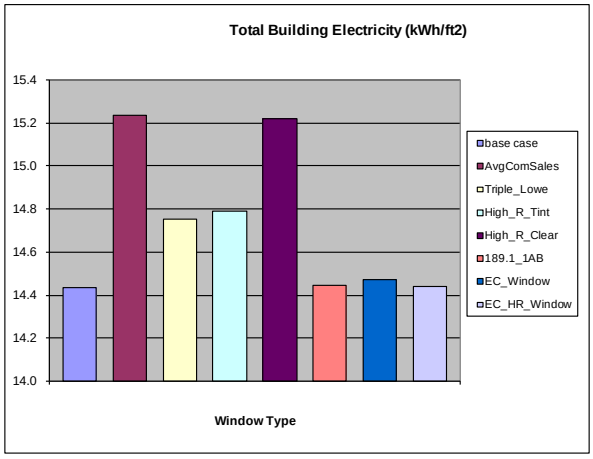
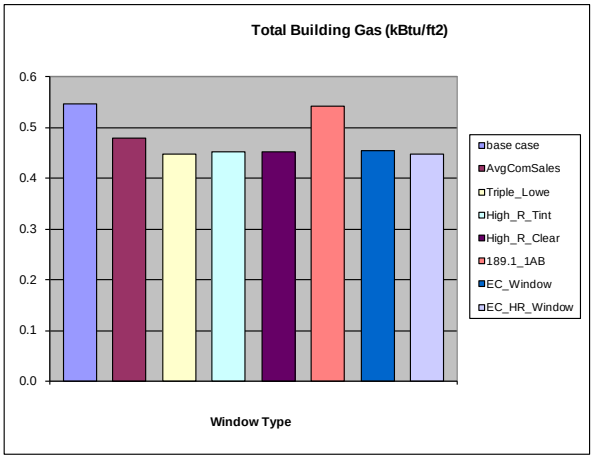
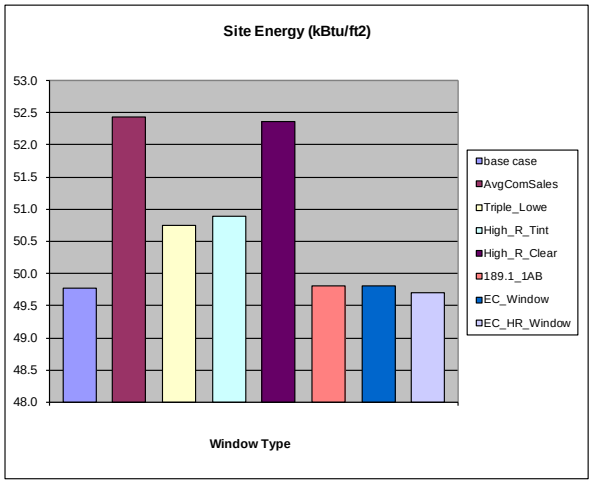
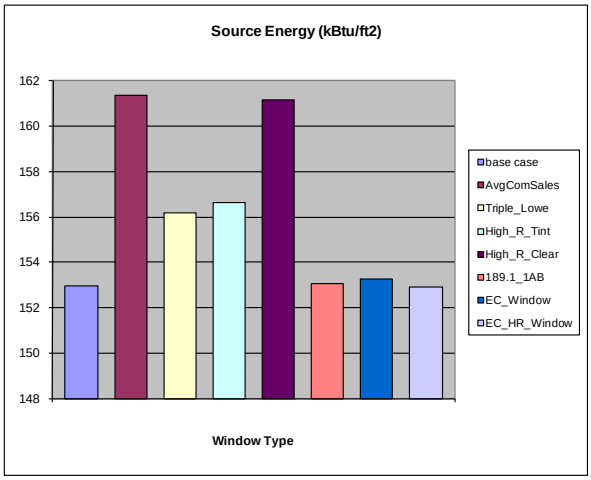

Visual Discomfort
Hours (Glare Index Exceeding the Max)
230
220
210
200
190
180
170
160
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

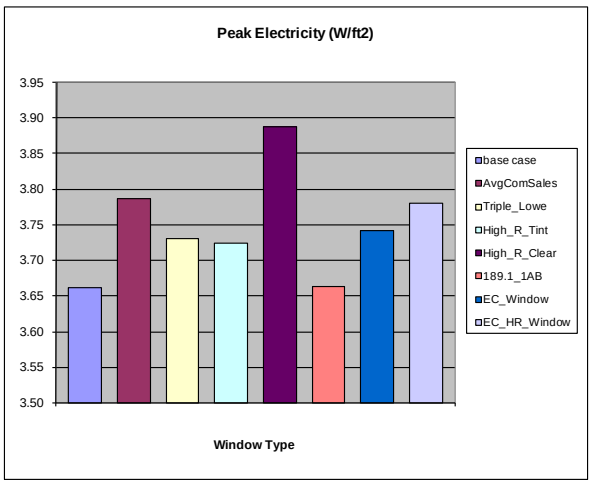
Figure 26 - For Miami – Shades on if high glare, no daylighting controls

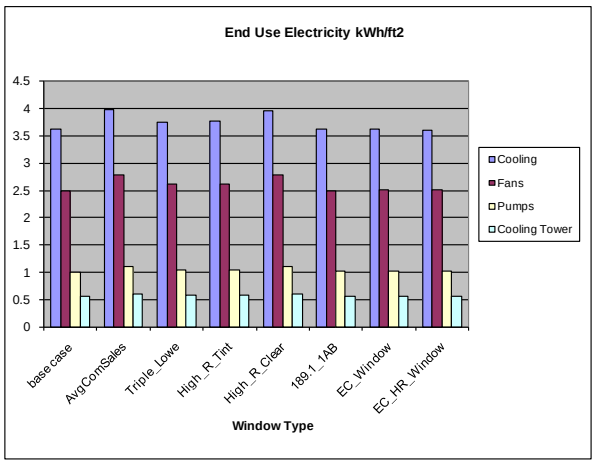


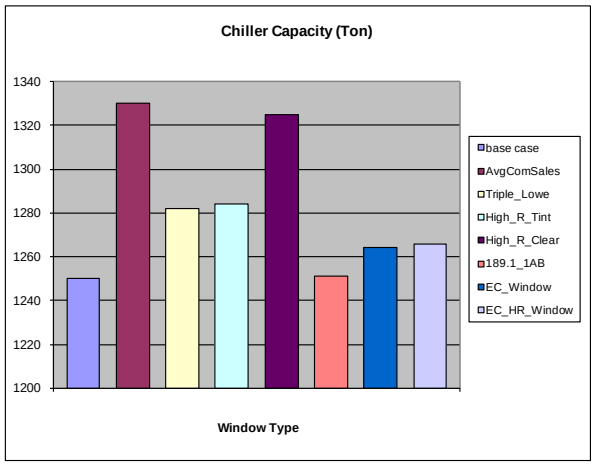


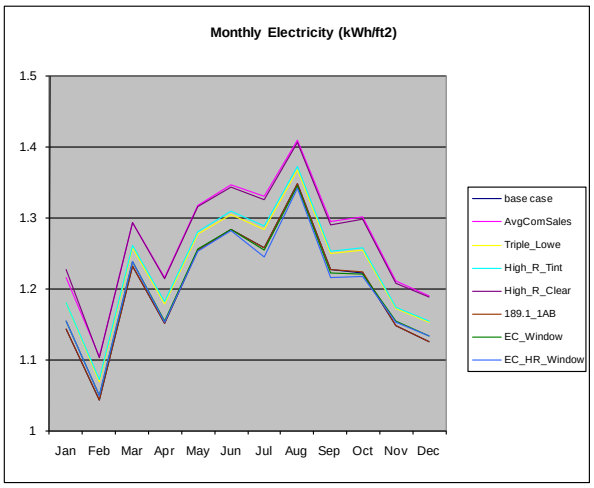


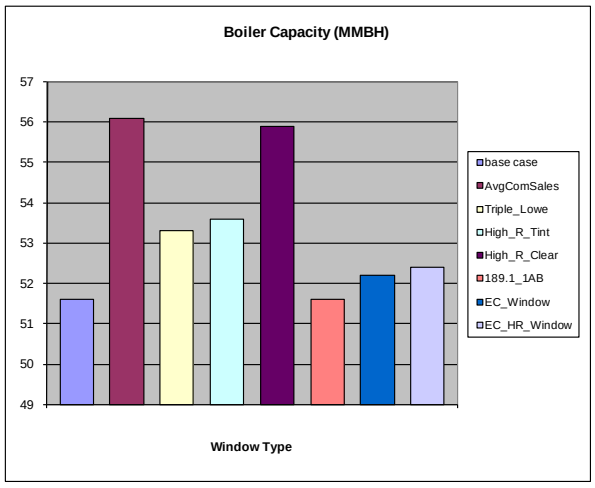





End Use Electricity kWh/ft2
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_1AB
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1340
1320
1300
1280
1260
1240
1220
1200
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_1AB
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.5
1.4
1.3
1.2
1.1
1
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_1AB
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
57
56
55
54
53
52
51
50
49
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_1AB
EC_Window
EC_HR_Window

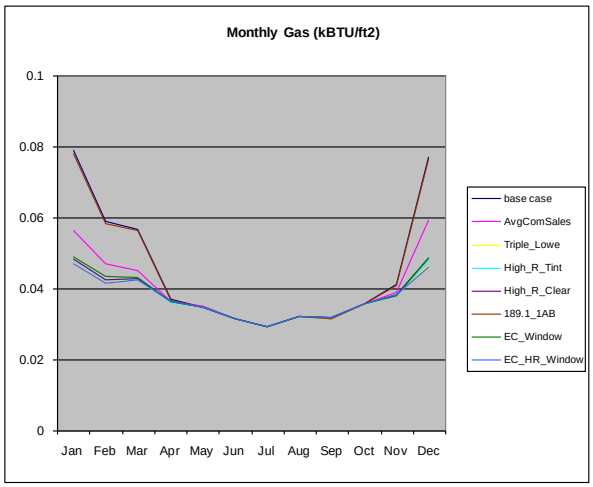
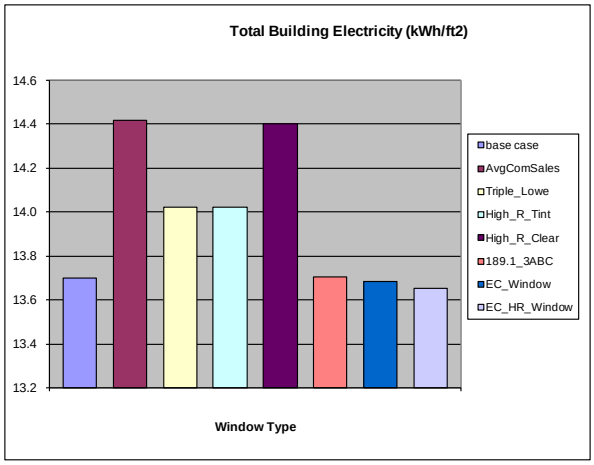
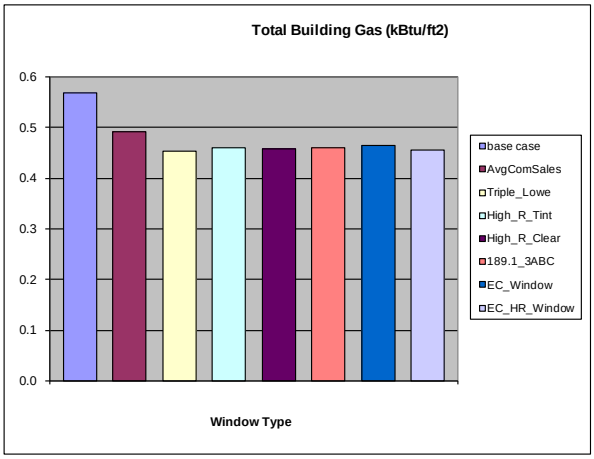
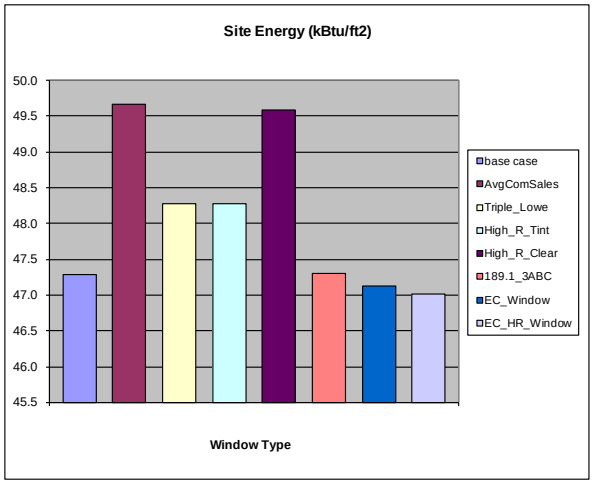
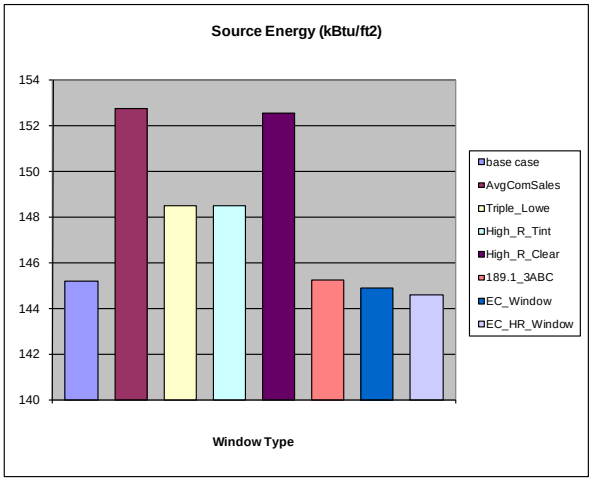

Monthly Gas (kBTU/ft2)
0.1
0.08
0.06
0.04
0.02
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_1AB
EC_Window
EC_HR_Window

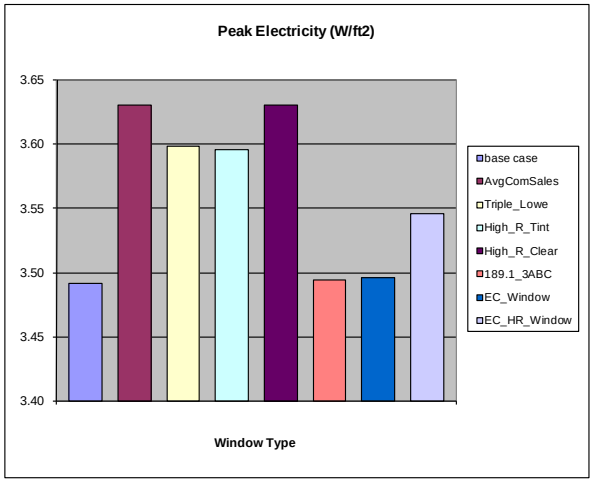
Figure 27 - For Miami – Shades on if high glare, with daylighting controls

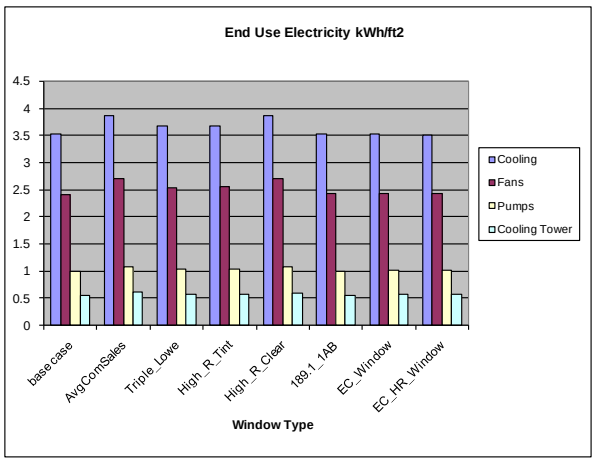


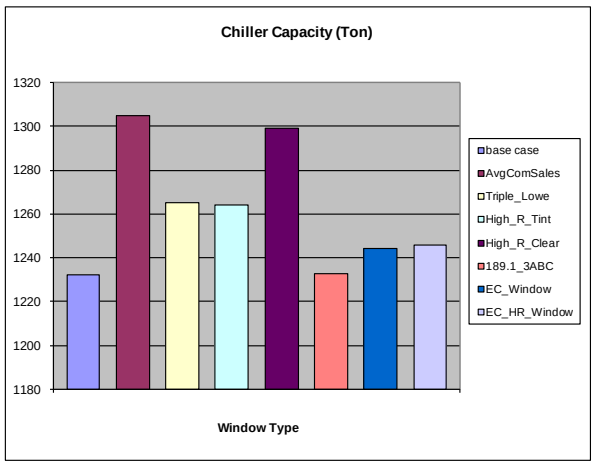


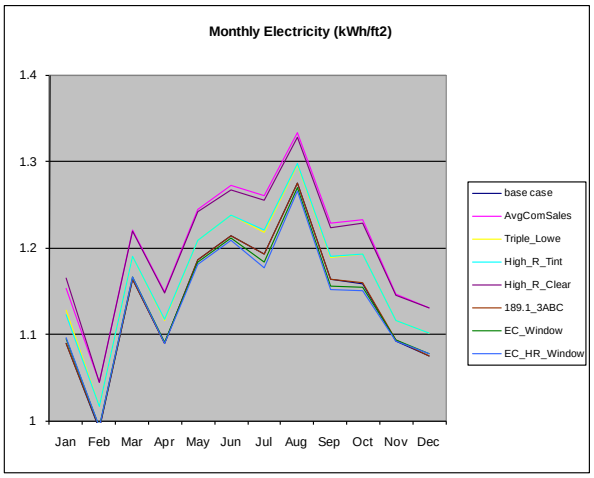


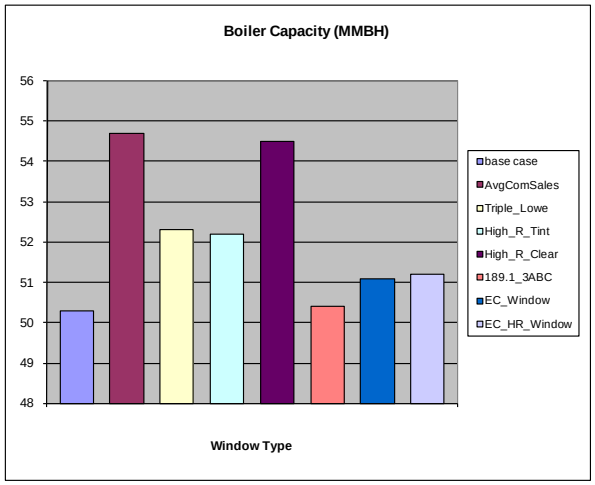





End Use Electricity kWh/ft2
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_1AB
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1320
1300
1280
1260
1240
1220
1200
1180
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.4
1.3
1.2
1.1
1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
56
55
54
53
52
51
50
49
48
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

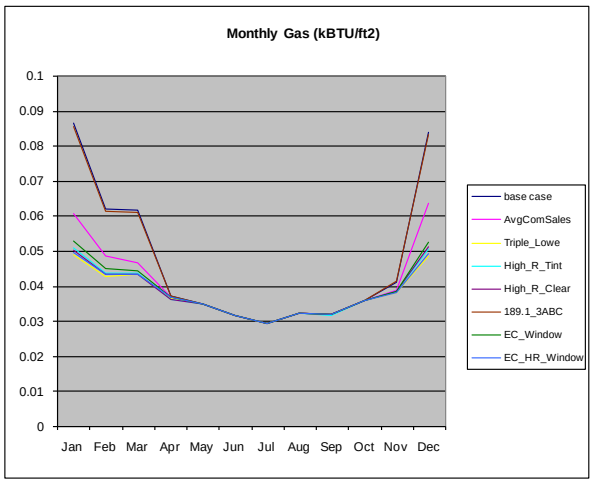
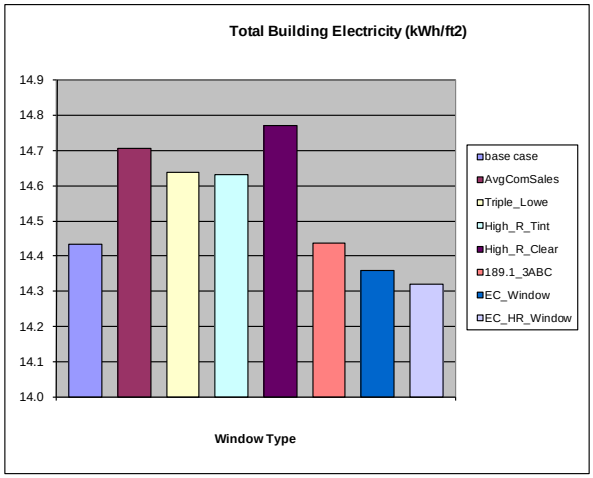
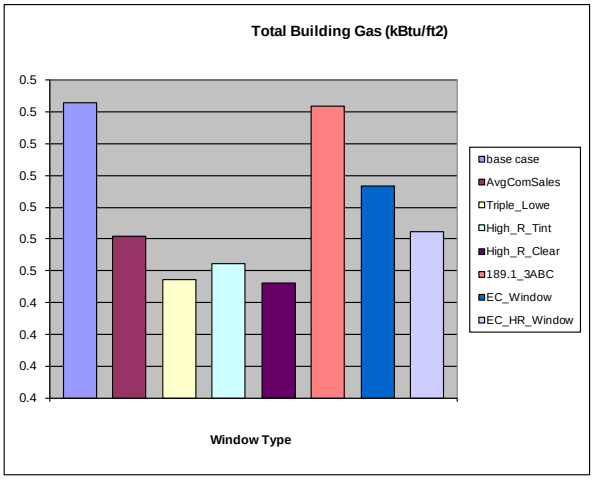
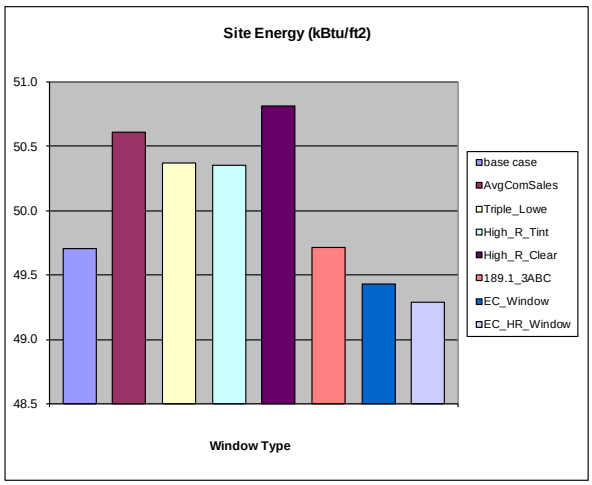
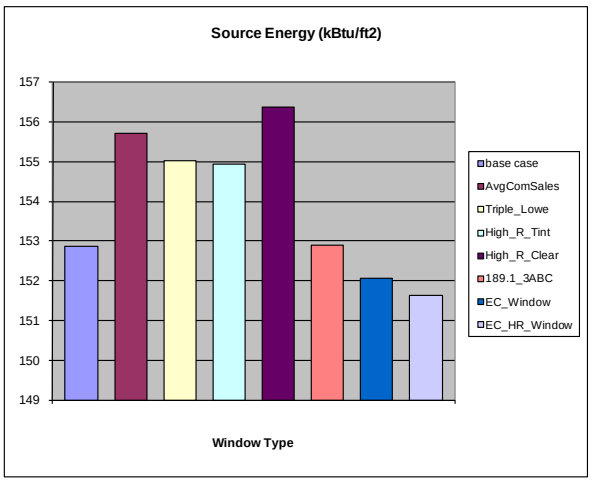

Monthly Gas (kBTU/ft2)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

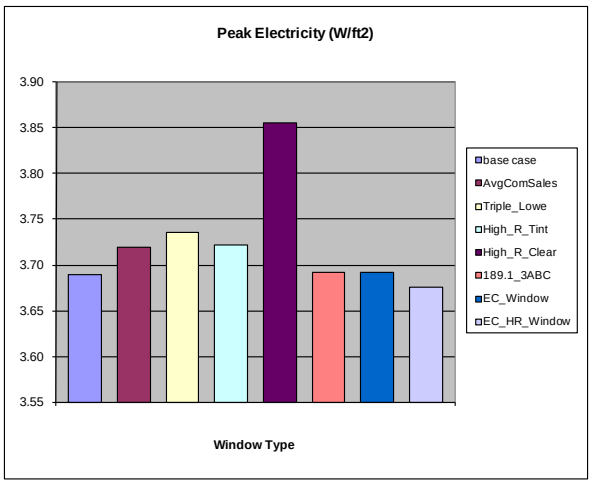
Figure 28 - For Miami – Shades always on, no daylighting controls

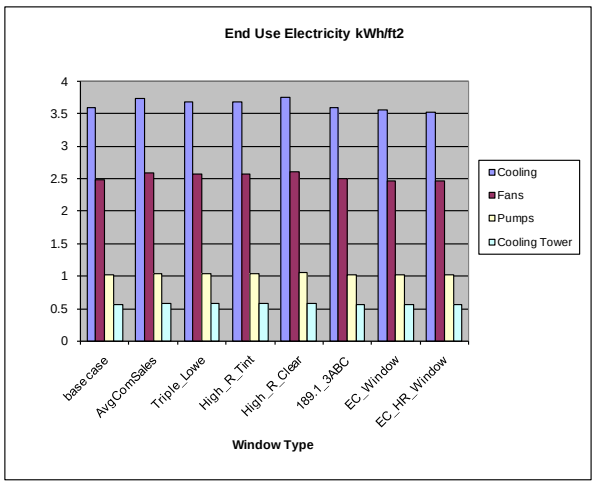


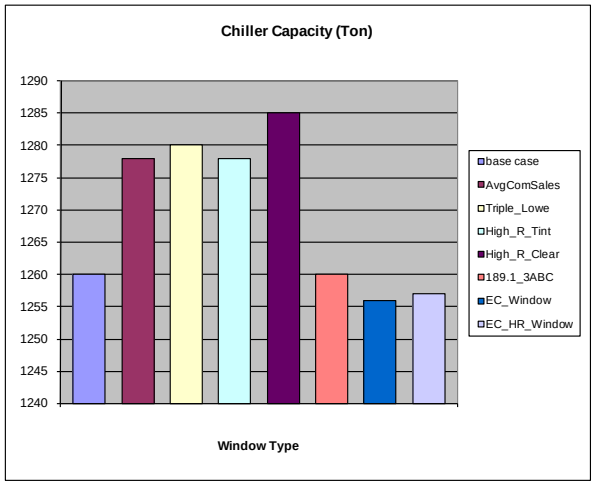


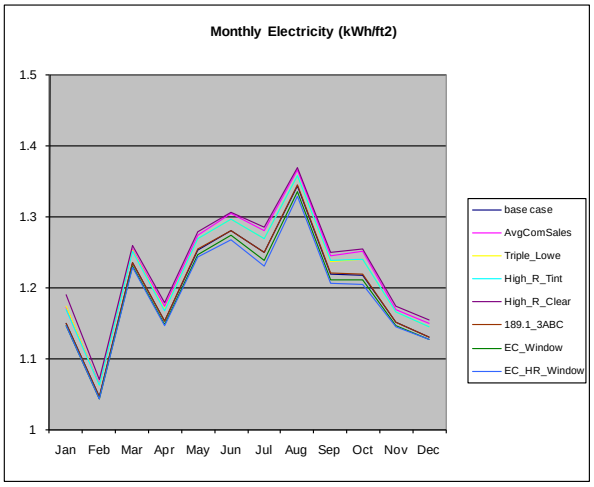


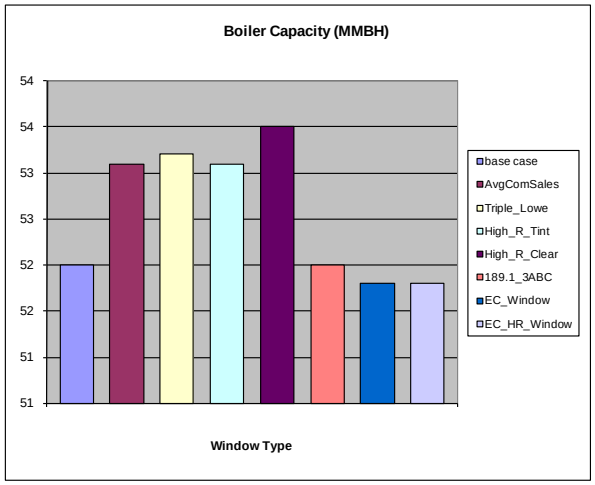





End Use Electricity kWh/ft2
4
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1290
1285
1280
1275
1270
1265
1260
1255
1250
1245
1240
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.5
1.4
1.3
1.2
1.1
1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
54
54
53
53
52
52
51
51
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

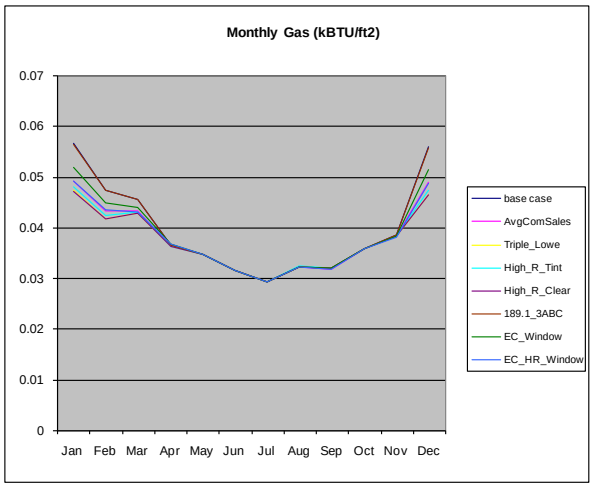
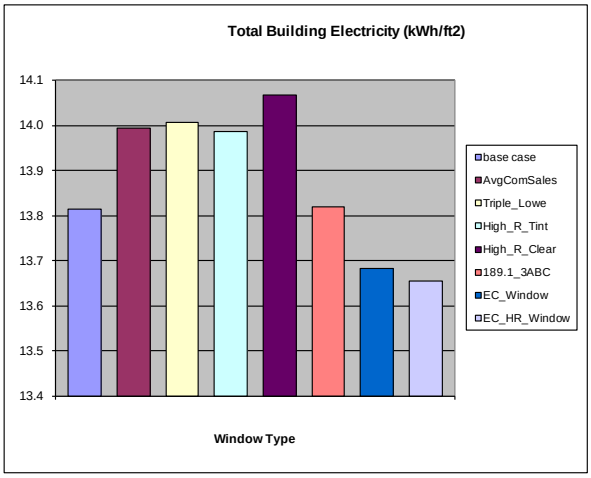
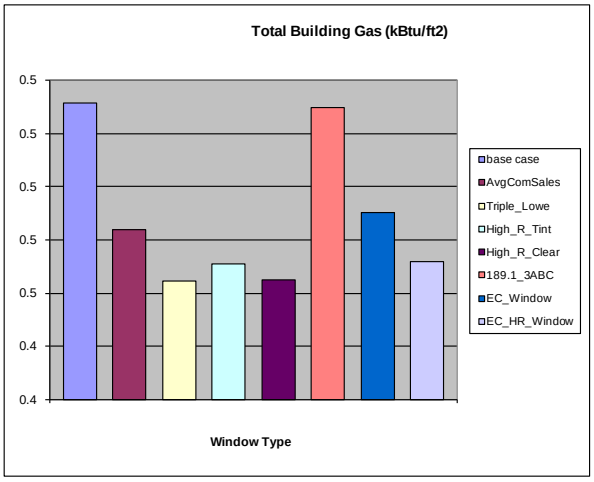
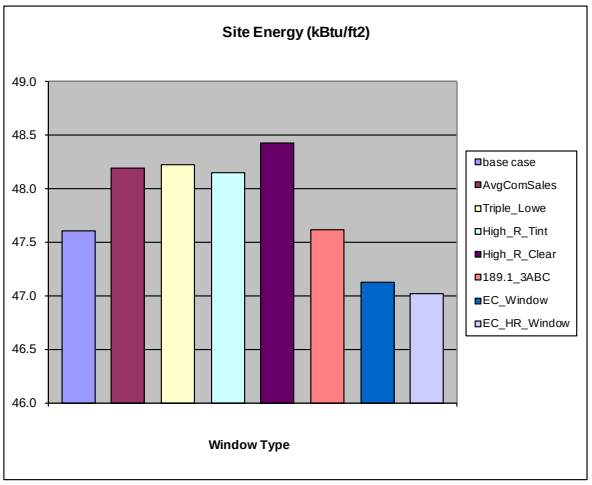
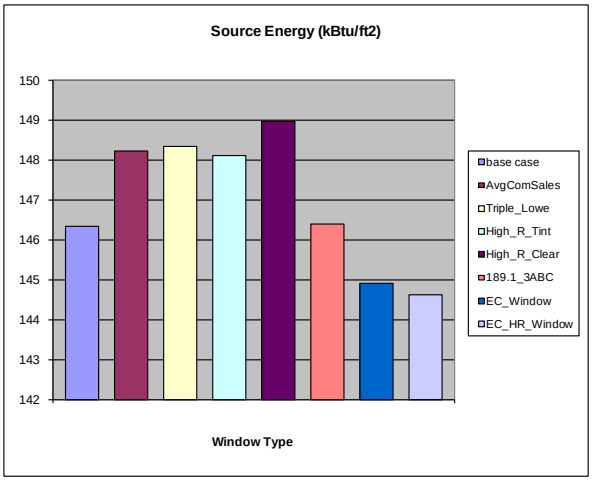

Monthly Gas (kBTU/ft2)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

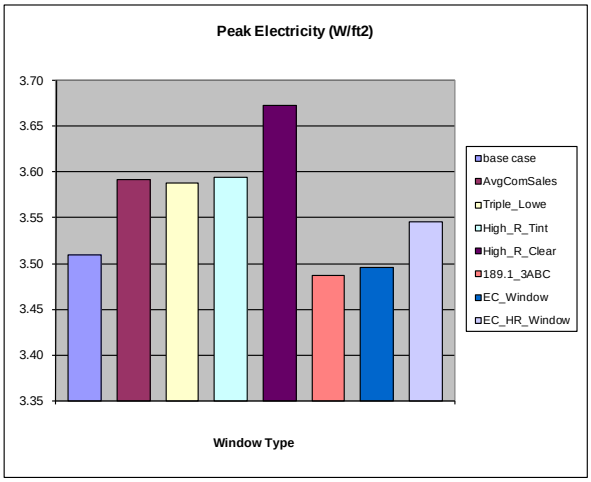
Figure 29 - For Miami – Shades always on, with daylighting controls

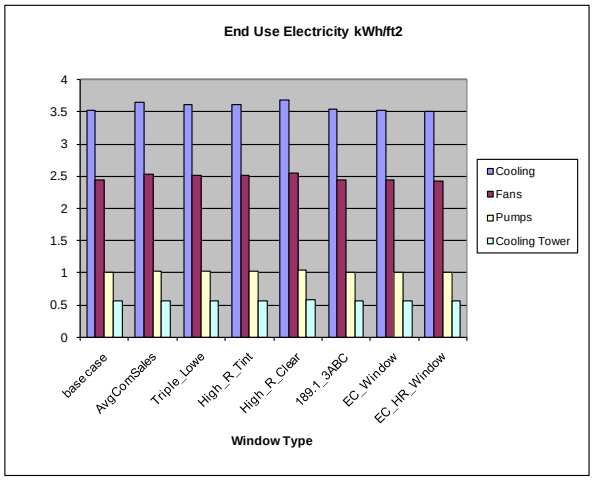


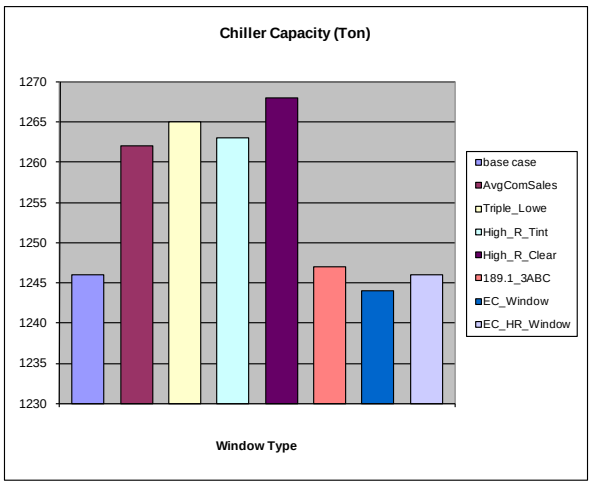


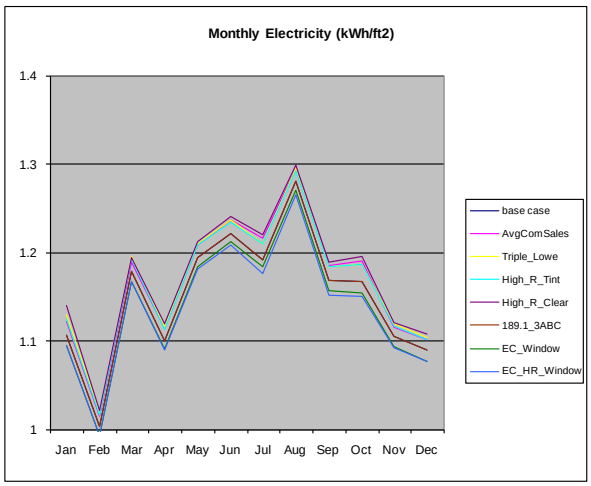


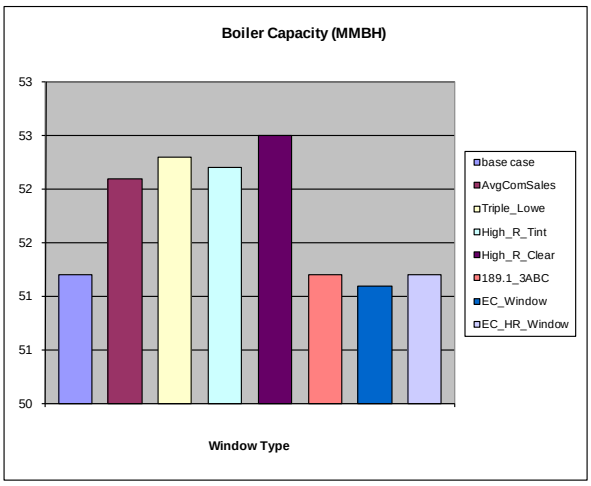





End Use Electricity kWh/ft2
4
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1270
1265
1260
1255
1250
1245
1240
1235
1230
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.4
1.3
1.2
1.1
1
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
53
53
52
52
51
51
50
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

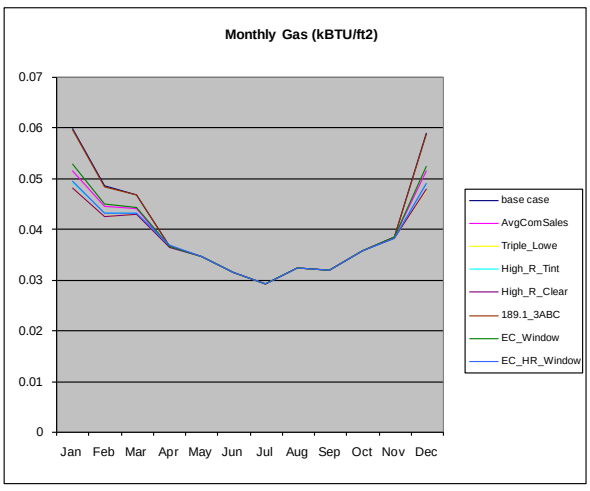
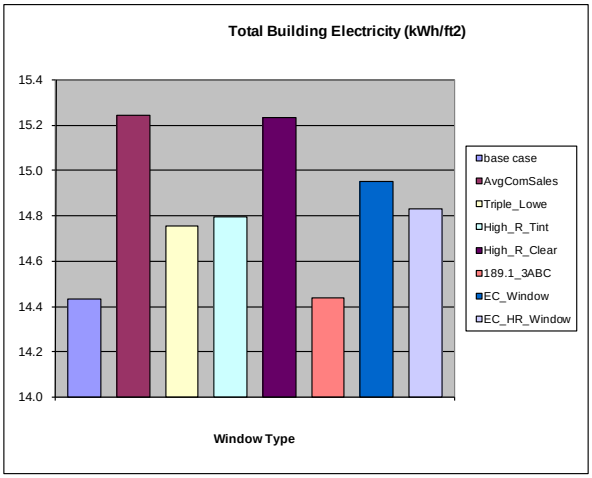
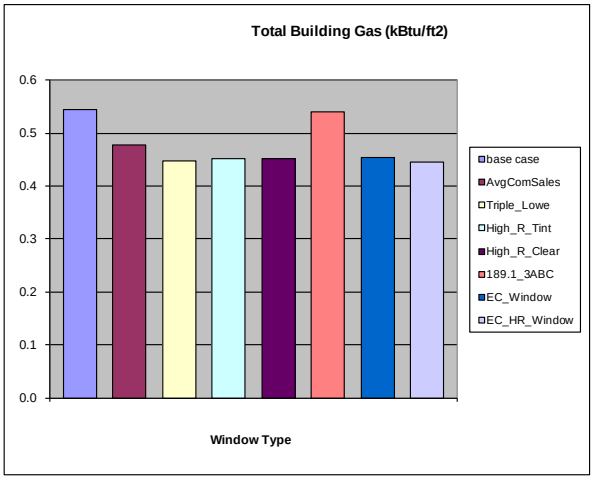
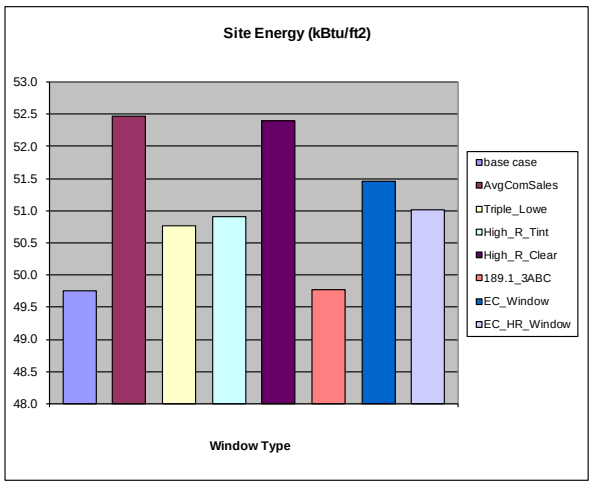
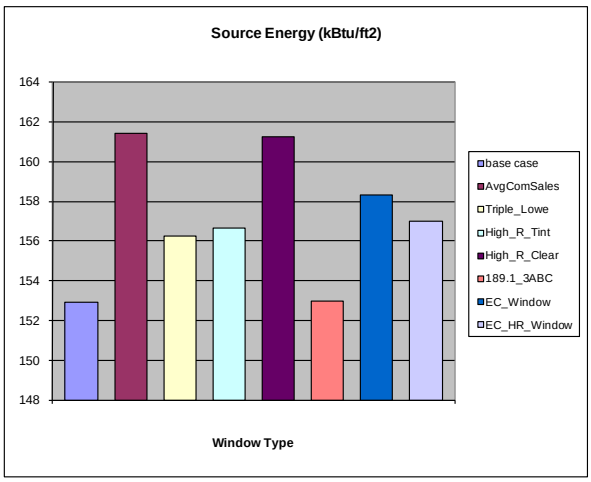

Monthly Gas (kBTU/ft2)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

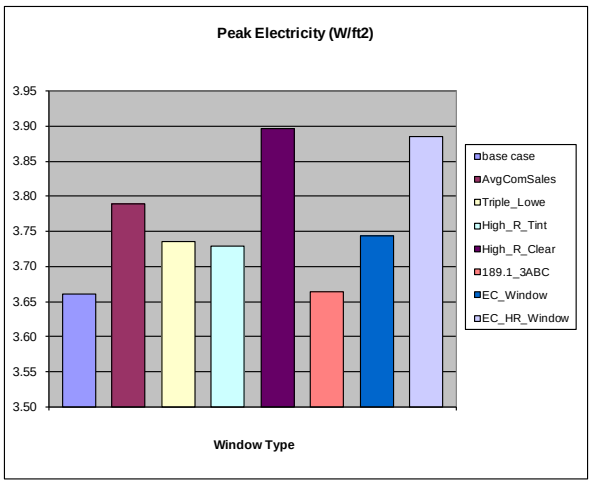
Figure 30 - For Miami – Shades always off, no daylighting controls

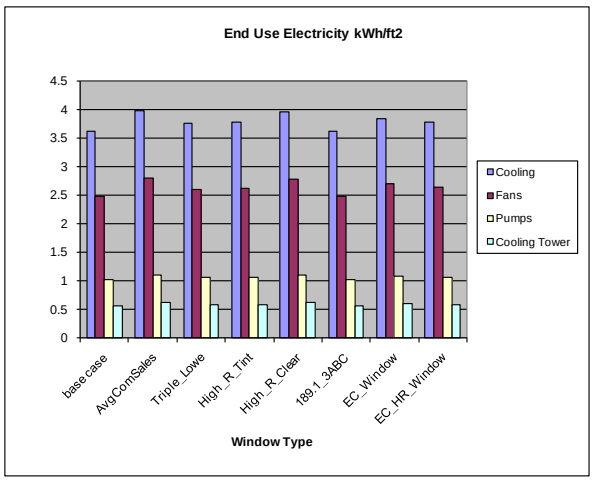


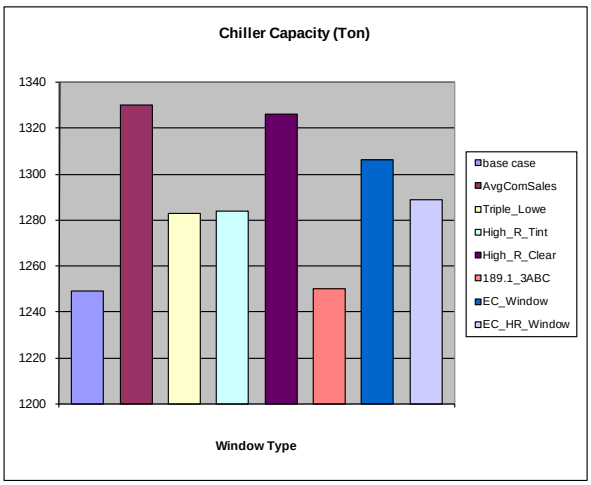


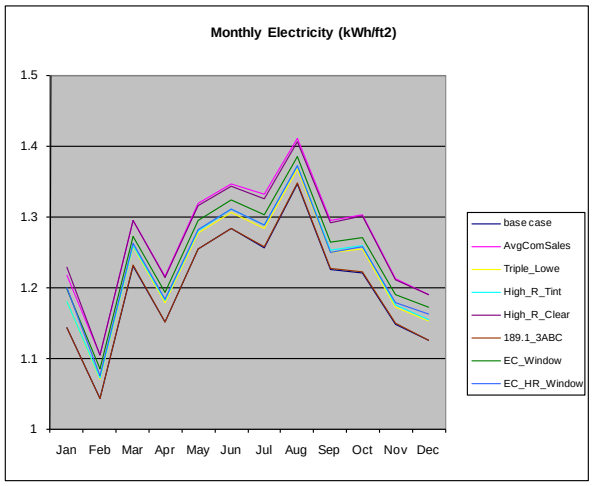


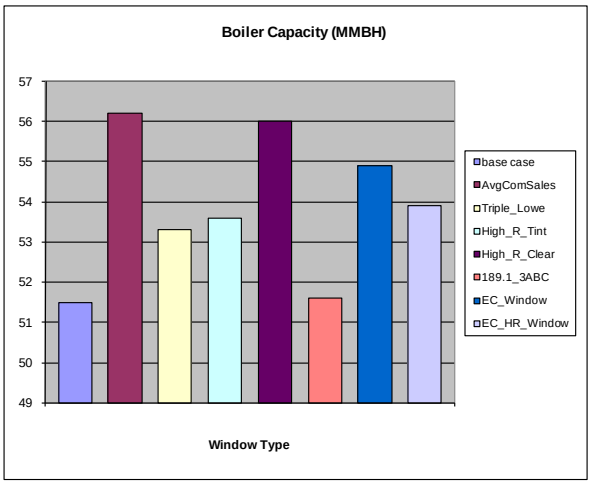


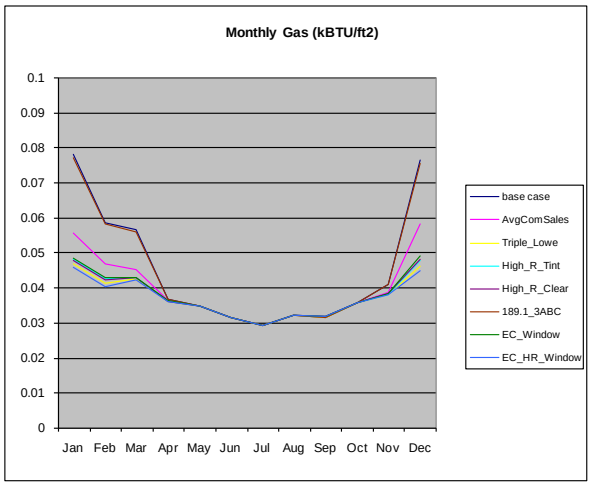



End Use Electricity kWh/ft2
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Cooling
Fans
Pumps
Cooling Tower
Window Type


Chiller Capacity (Ton)
1340
1320
1300
1280
1260
1240
1220
1200
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Monthly Electricity (kWh/ft2)
1.5
1.4
1.3
1.2
1.1
1
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
57
56
55
54
53
52
51
50
49
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Monthly Gas (kBTU/ft2)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

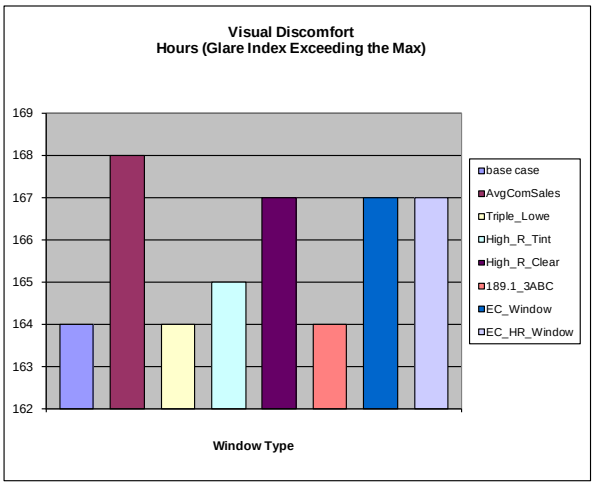
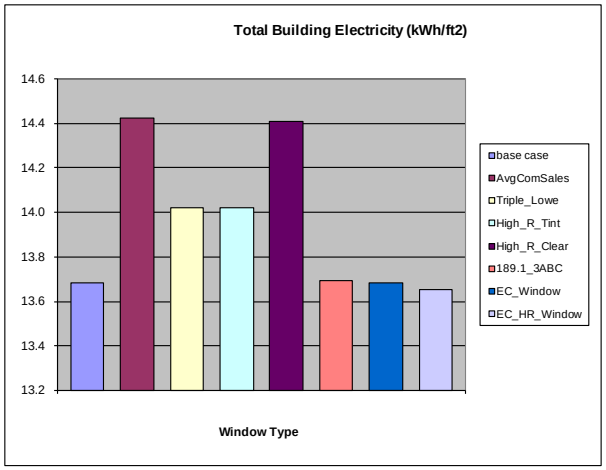
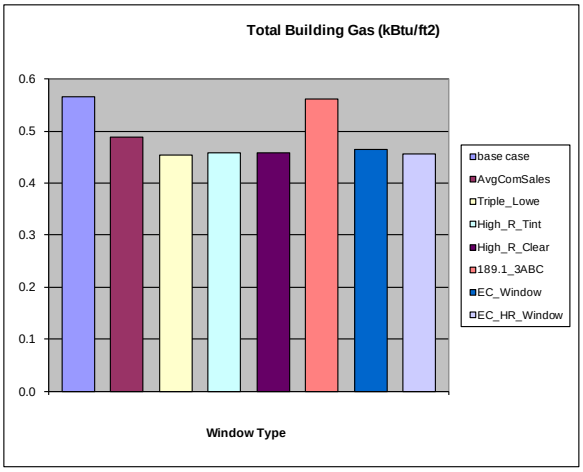
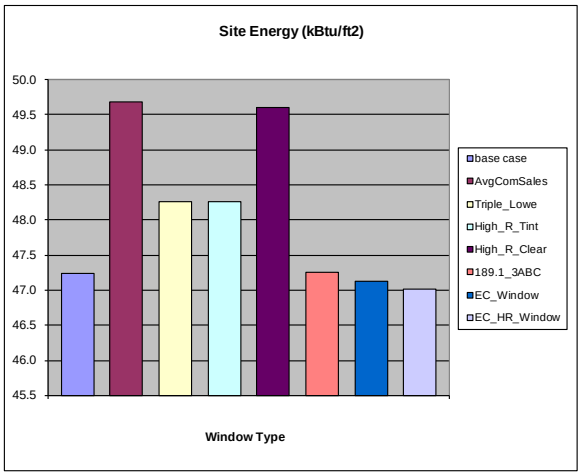
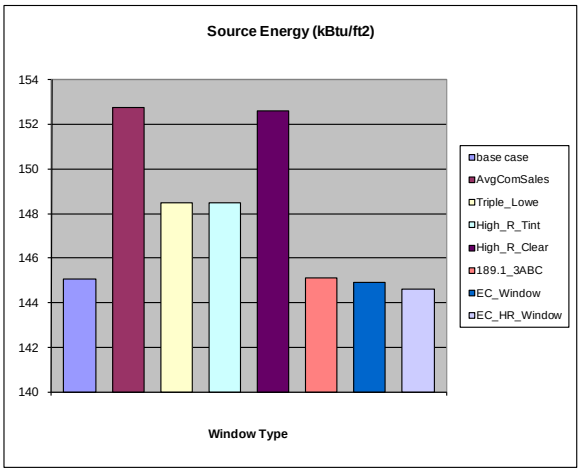

Visual Discomfort
Hours (Glare Index Exceeding the Max)
169
168
167
166
165
164
163
162
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type

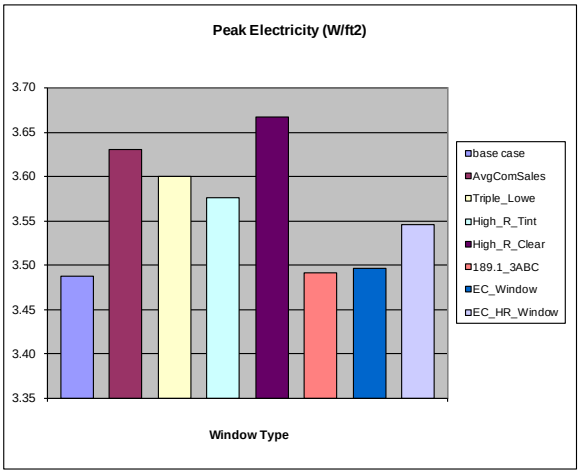
Figure 31 - For Miami – Shades always off, with daylighting controls

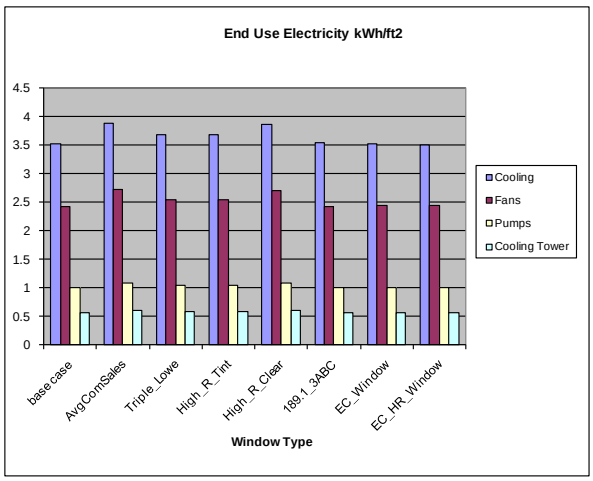


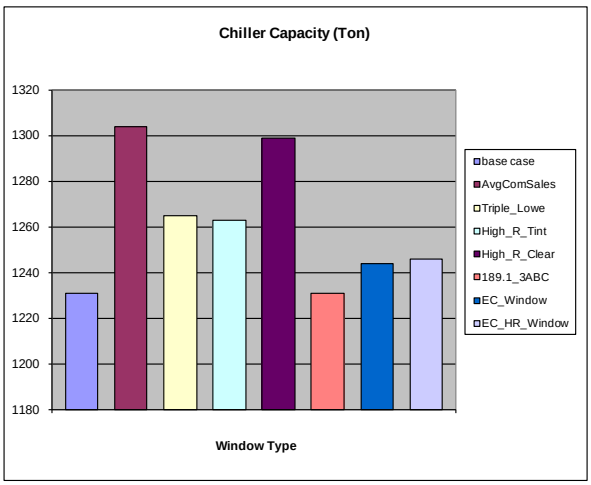


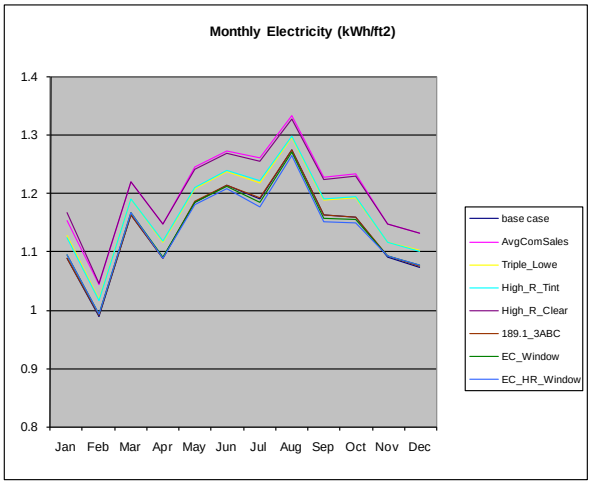


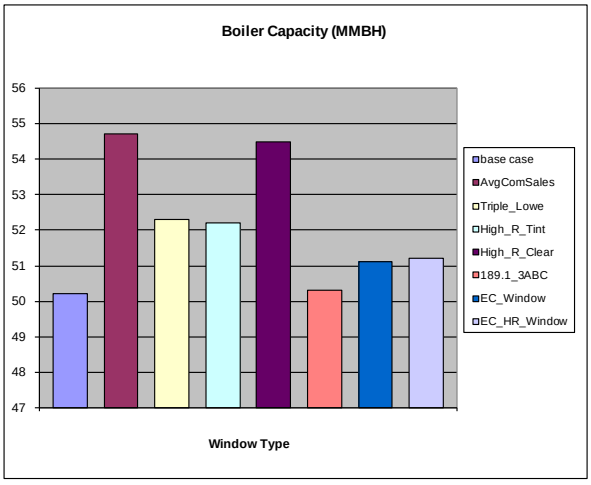


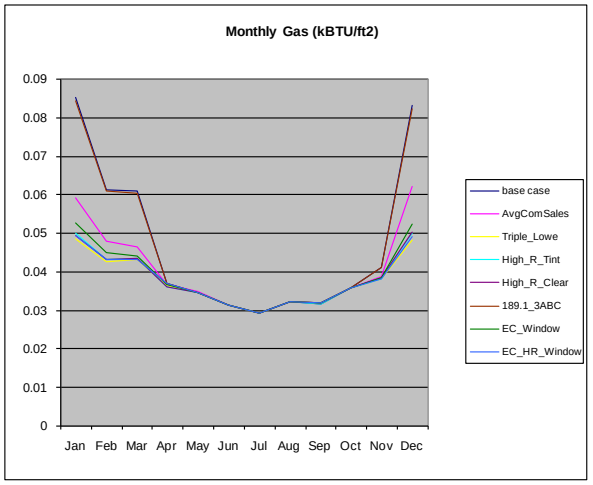



End Use Electricity kWh/ft2
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1320
1300
1280
1260
1240
1220
1200
1180
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.4
1.3
1.2
1.1
1
0.9
0.8
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
56
55
54
53
52
51
50
49
48
47
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Gas (kBTU/ft2)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

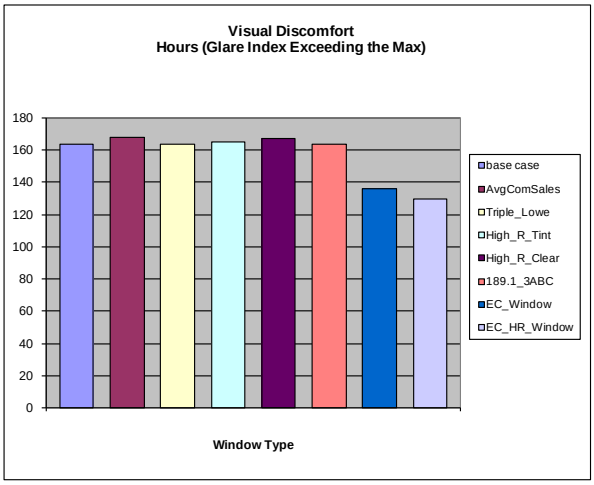
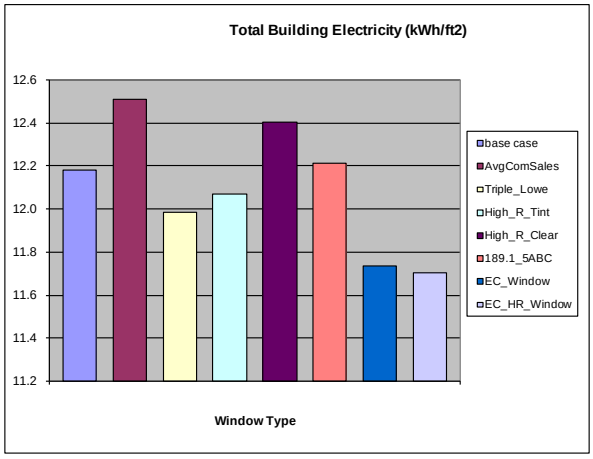
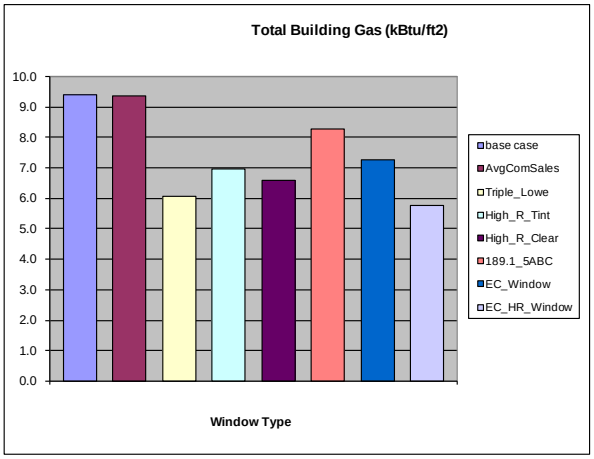
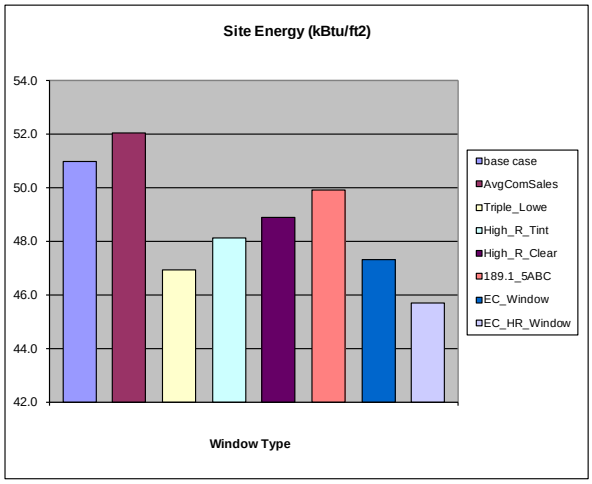
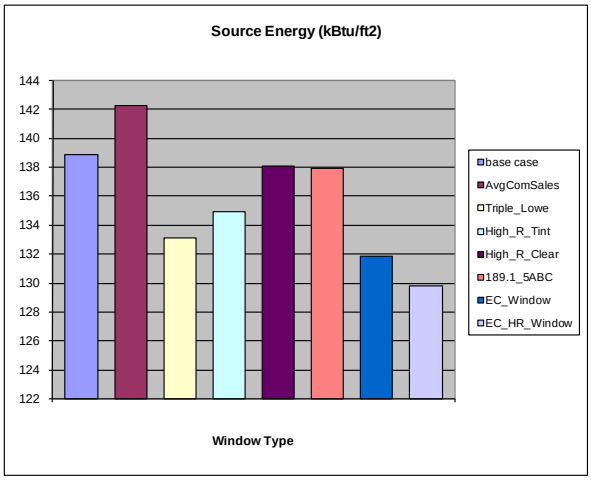

Visual Discomfort
Hours (Glare Index Exceeding the Max)
180
160
140
120
100
80
60
40
20
0
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

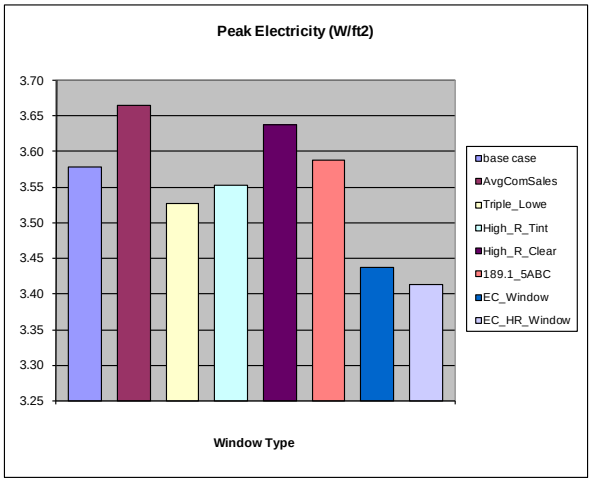
Figure 32 - For Chicago – Shades on if high glare, no daylighting controls

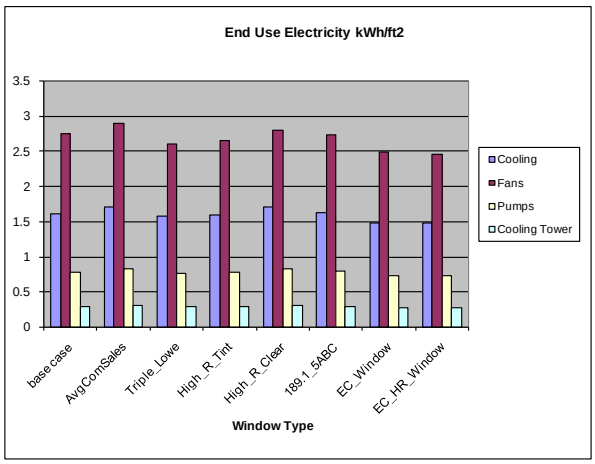


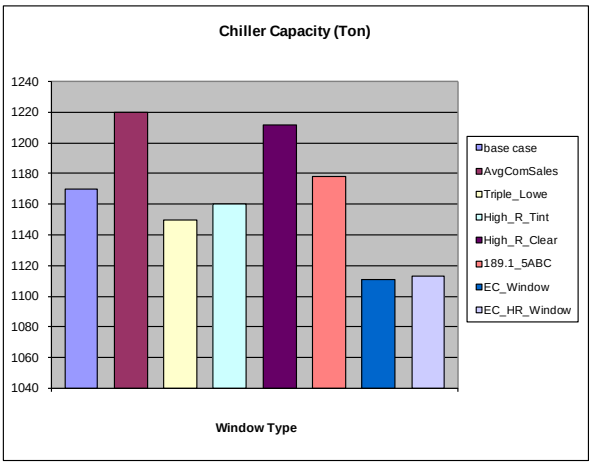


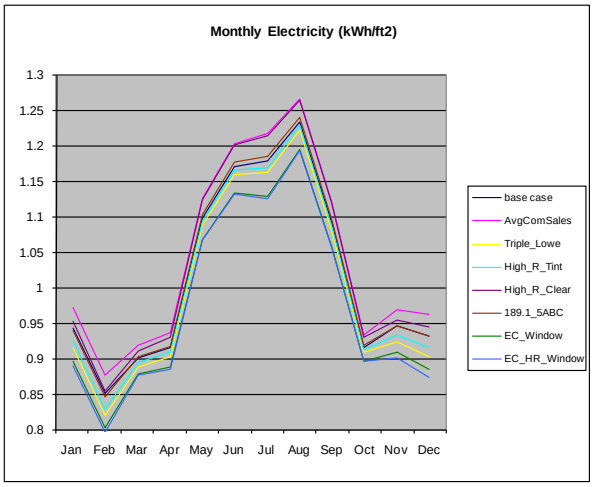


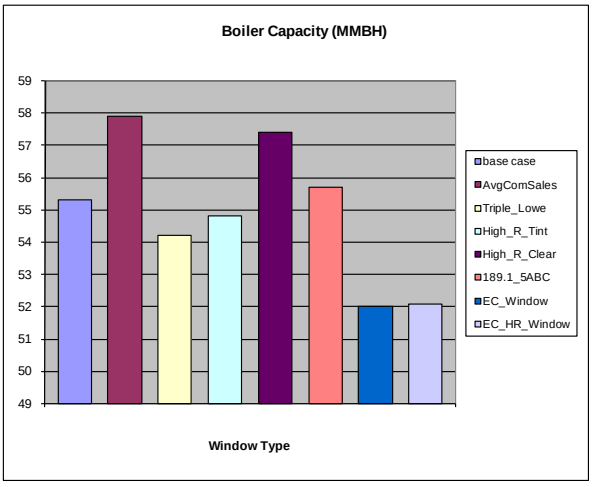





End Use Electricity kWh/ft2
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_5ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1240
1220
1200
1180
1160
1140
1120
1100
1080
1060
1040
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_5ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_5ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
59
58
57
56
55
54
53
52
51
50
49
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_5ABC
EC_Window
EC_HR_Window

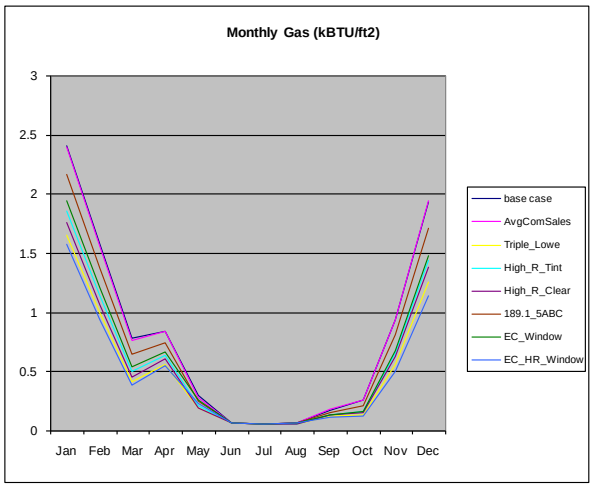
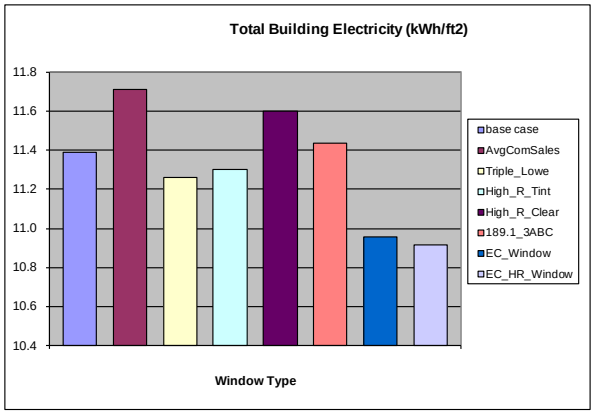
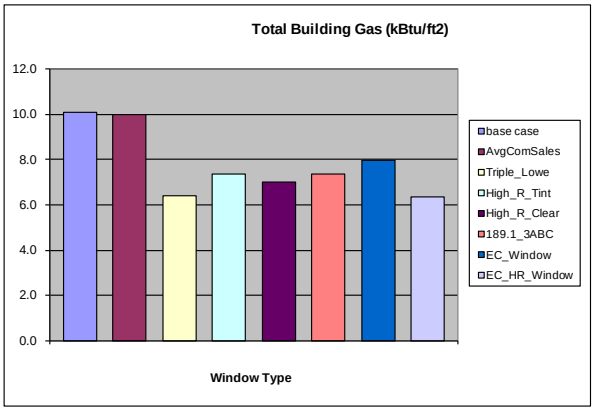
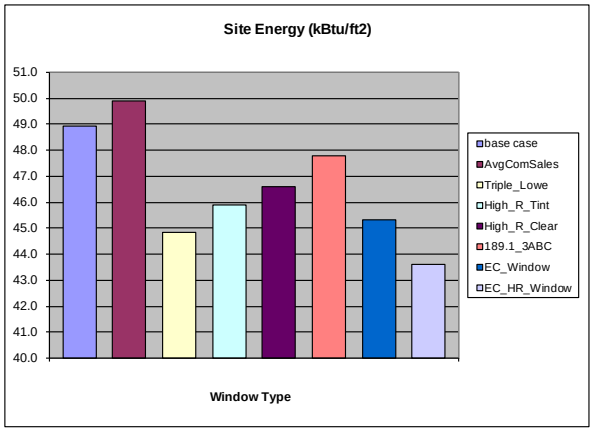
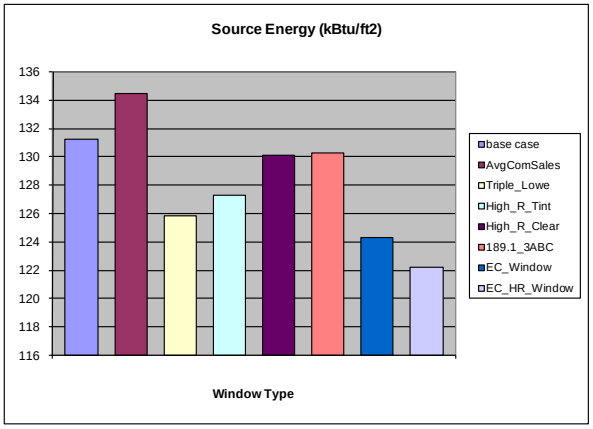

Monthly Gas (kBTU/ft2)
3
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_5ABC
EC_Window
EC_HR_Window

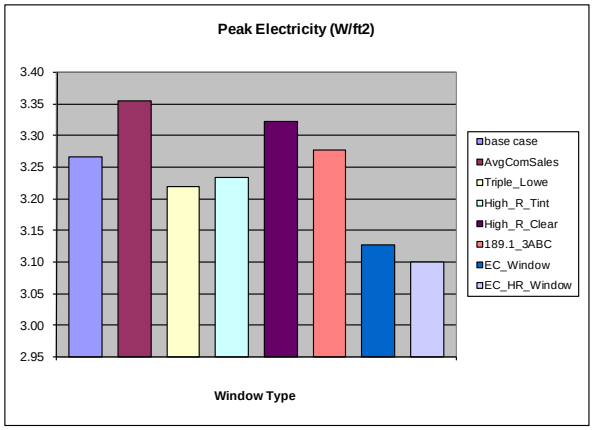
Figure 33 - For Chicago – Shades on if high glare, with daylighting controls

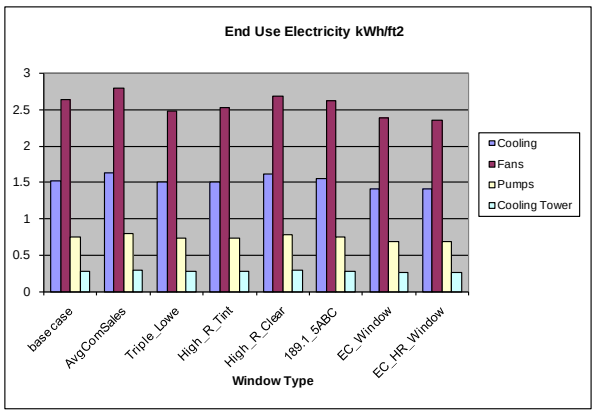


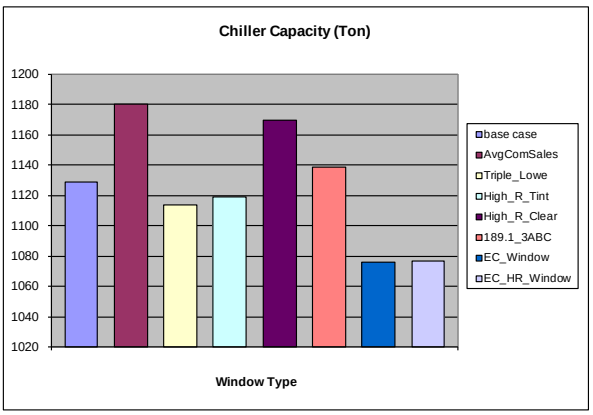


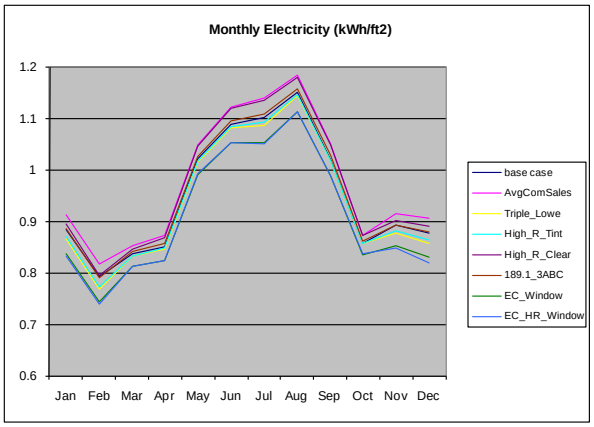


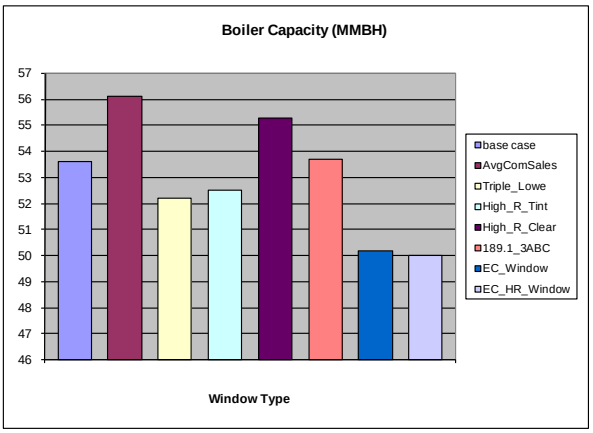





End Use Electricity kWh/ft2
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_5ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1200
1180
1160
1140
1120
1100
1080
1060
1040
1020
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.2
1.1
1
0.9
0.8
0.7
0.6
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
57
56
55
54
53
52
51
50
49
48
47
46
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

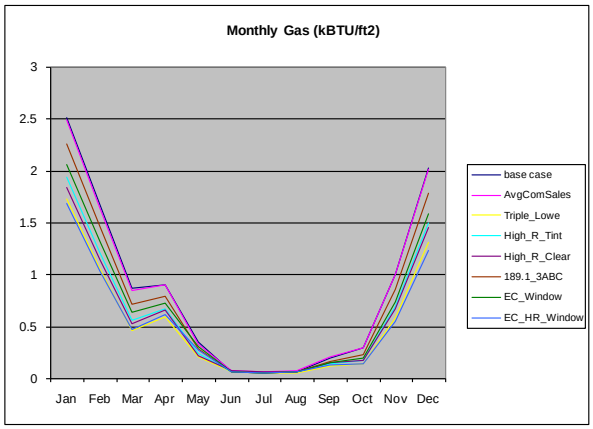
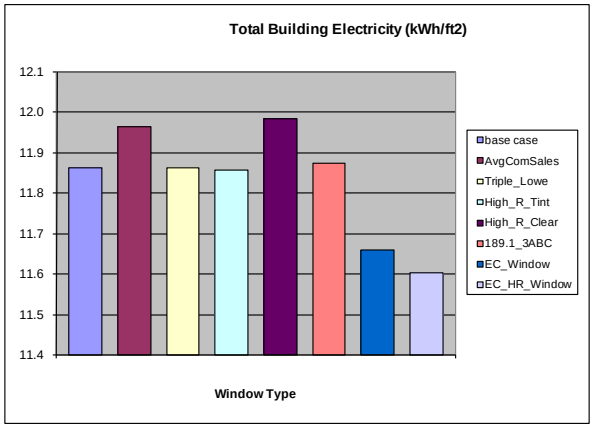
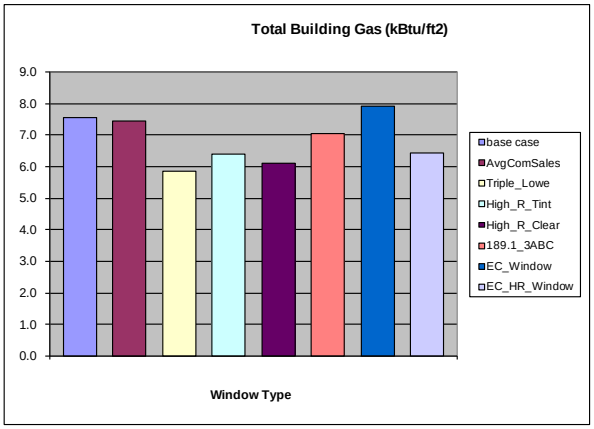
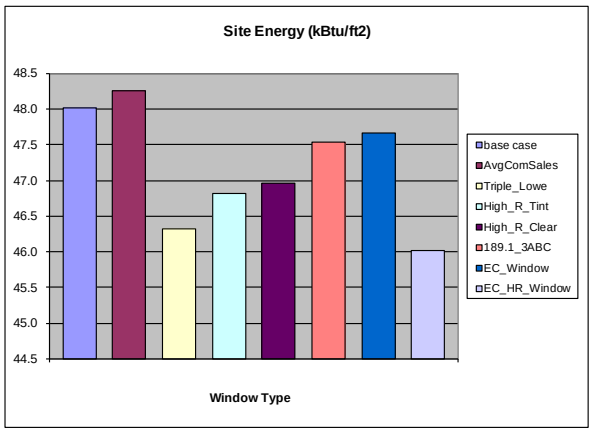
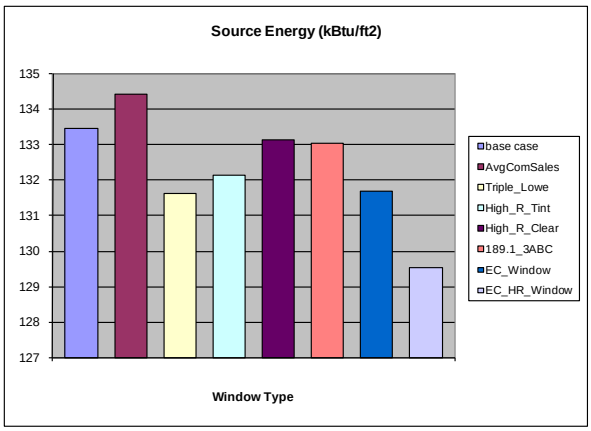

Monthly Gas (kBTU/ft2)
3
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

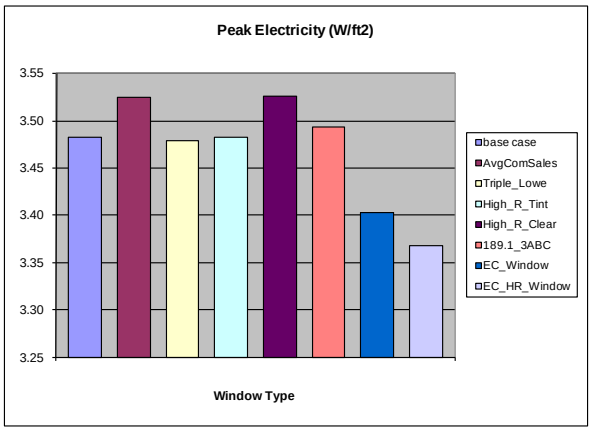
Figure 34 - For Chicago – Shades always on, no daylighting controls

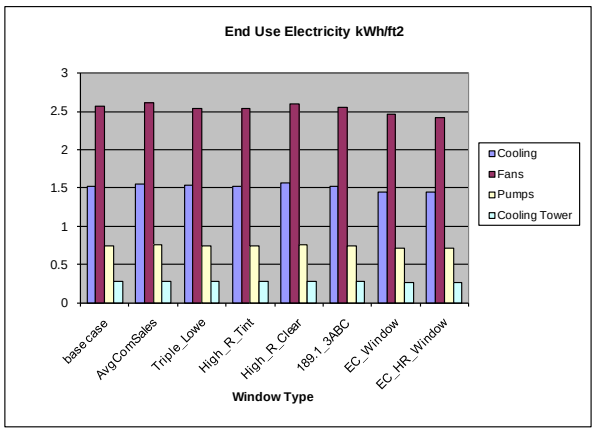


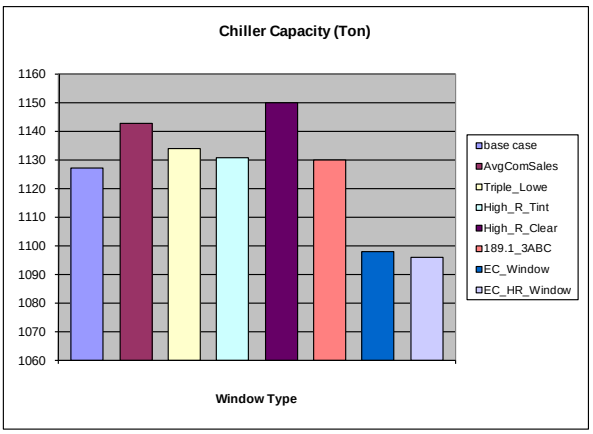


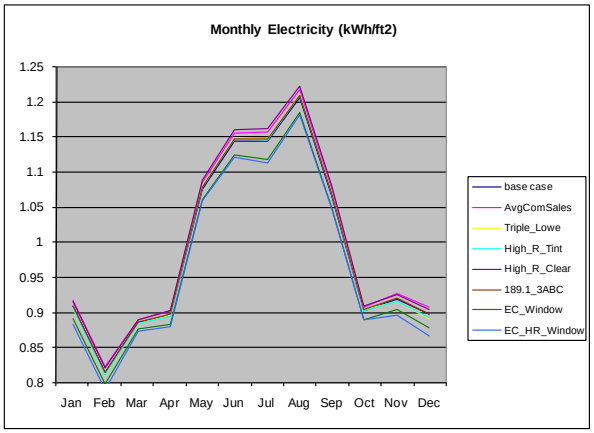


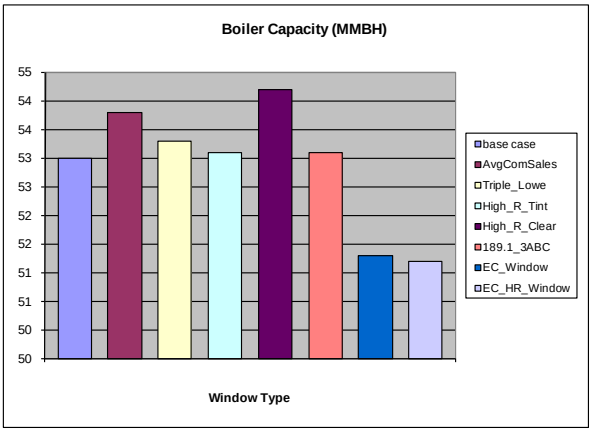





End Use Electricity kWh/ft2
3
2.5
2
1.5
1
0.5
0
Cooling
Fans
Pumps
Cooling Tower
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Chiller Capacity (Ton)
1160
1150
1140
1130
1120
1110
1100
1090
1080
1070
1060
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Monthly Electricity (kWh/ft2)
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
55
54
54
53
53
52
52
51
51
50
50
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type

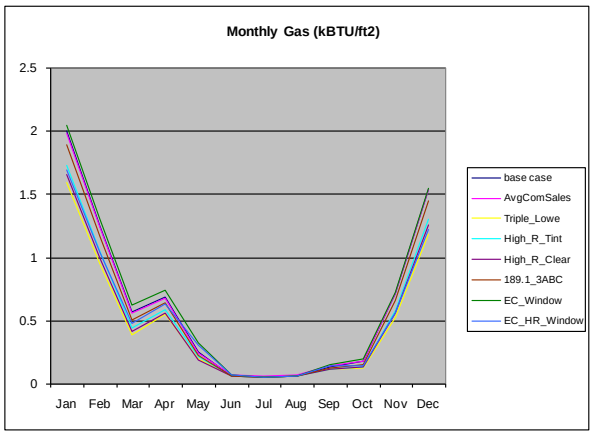
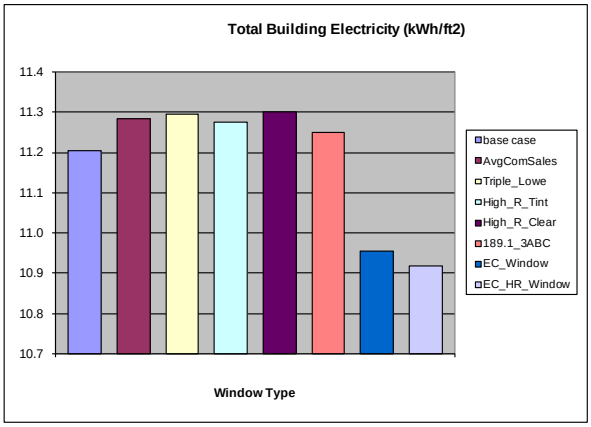
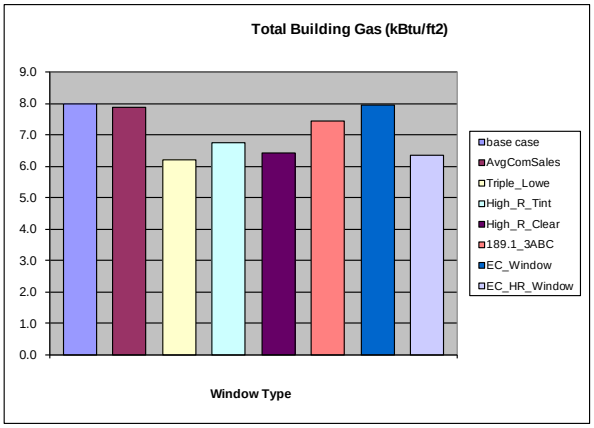
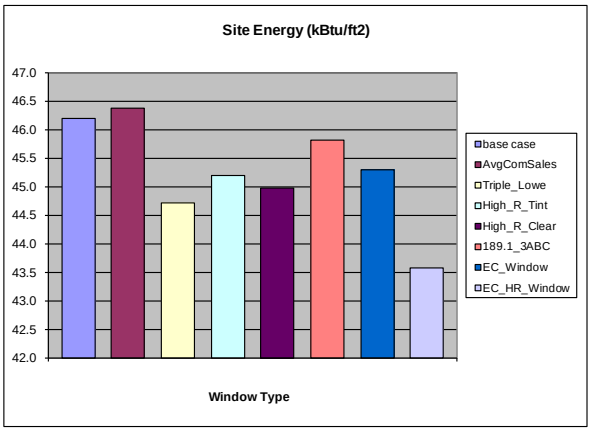
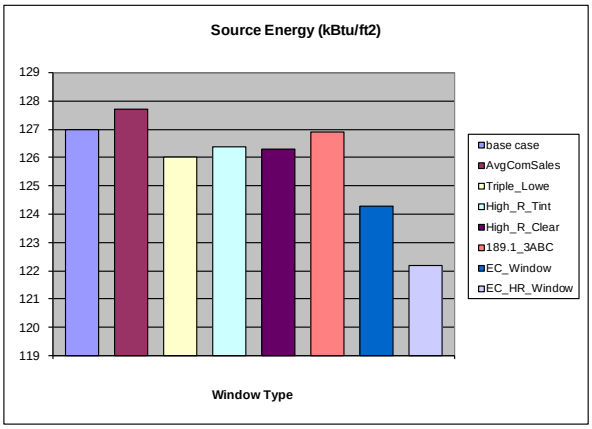

Monthly Gas (kBTU/ft2)
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

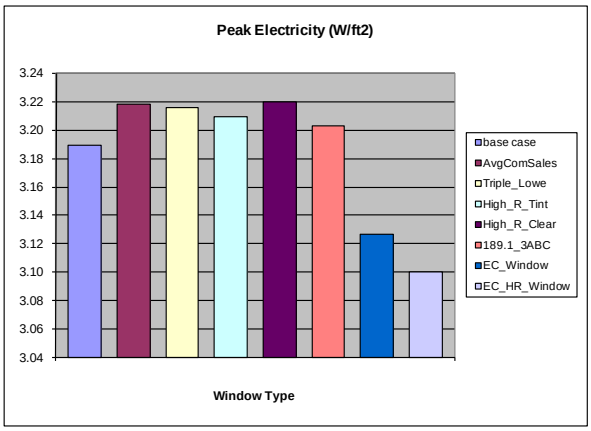
Figure 35 - For Chicago – Shades always on, with daylighting controls

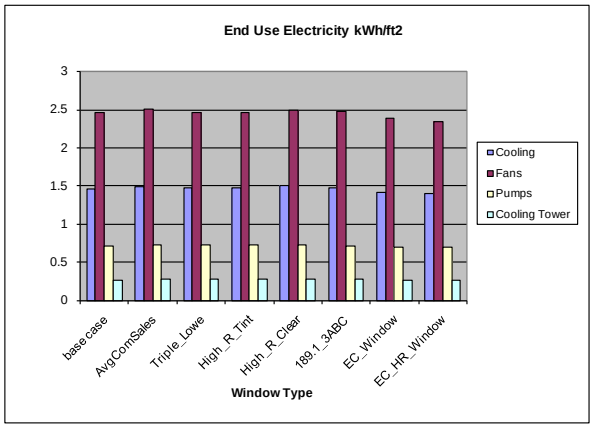


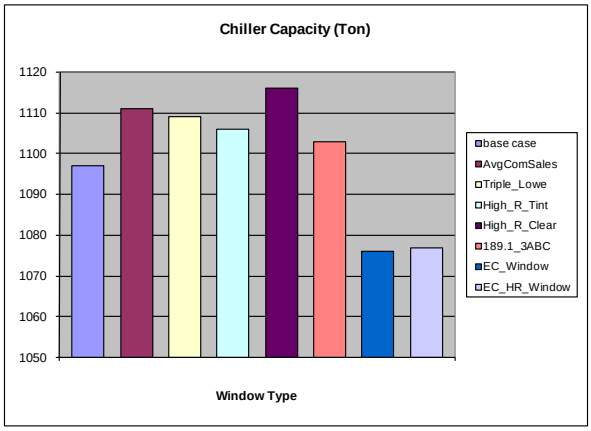


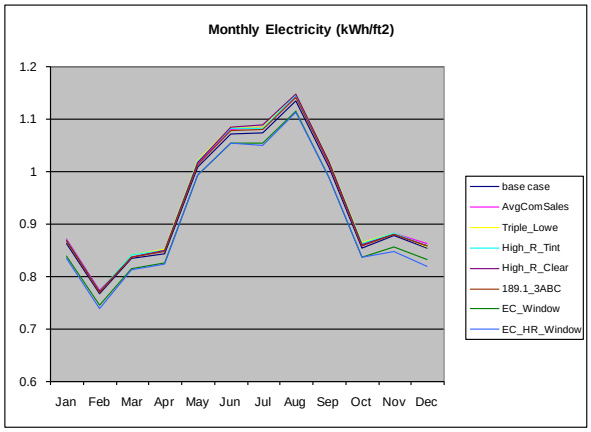


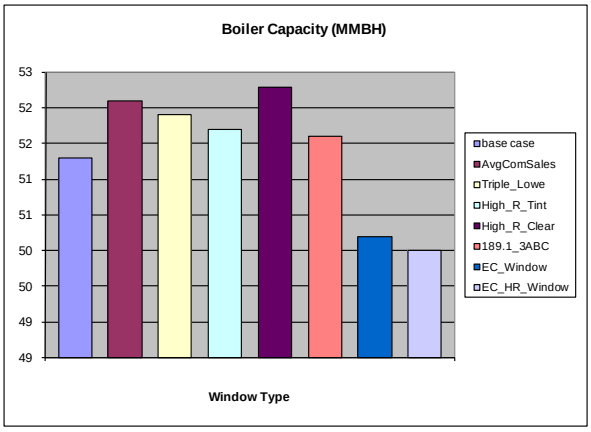





End Use Electricity kWh/ft2
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1120
1110
1100
1090
1080
1070
1060
1050
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.2
1.1
1
0.9
0.8
0.7
0.6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
53
52
52
51
51
50
50
49
49
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

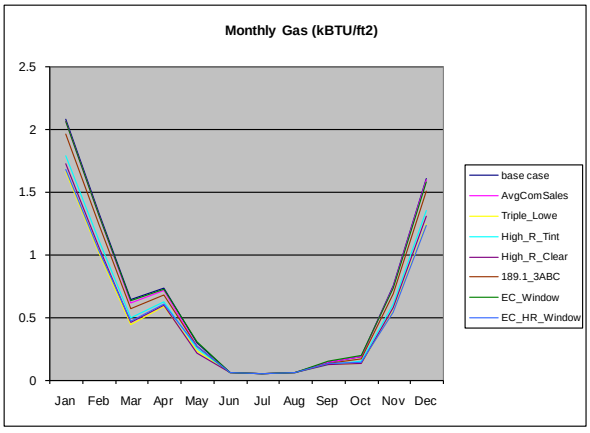
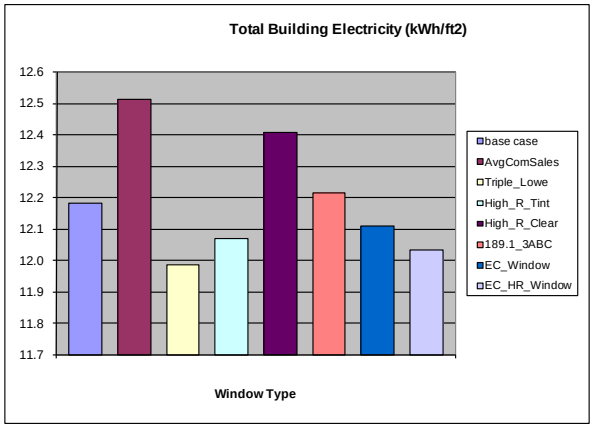
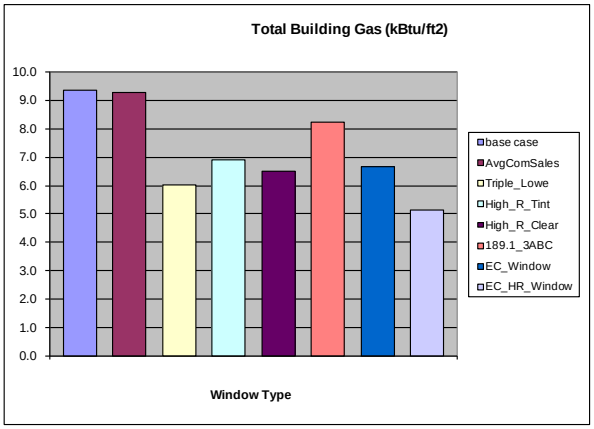
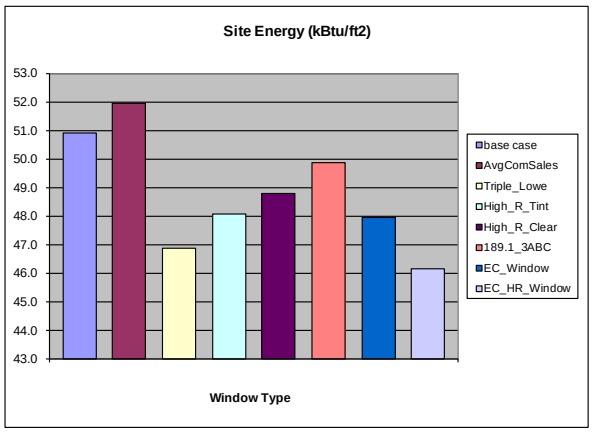
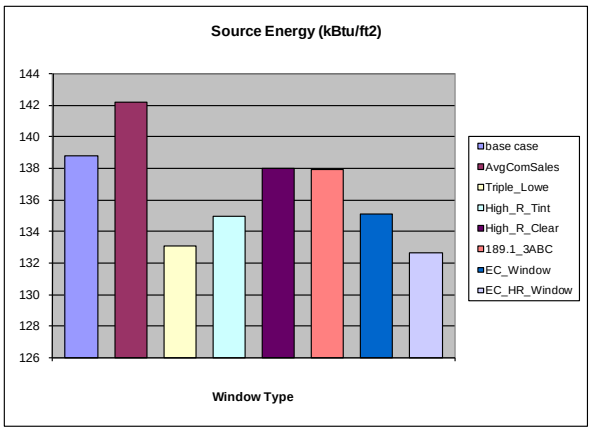

Monthly Gas (kBTU/ft2)
2.5
2
1.5
1
0.5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

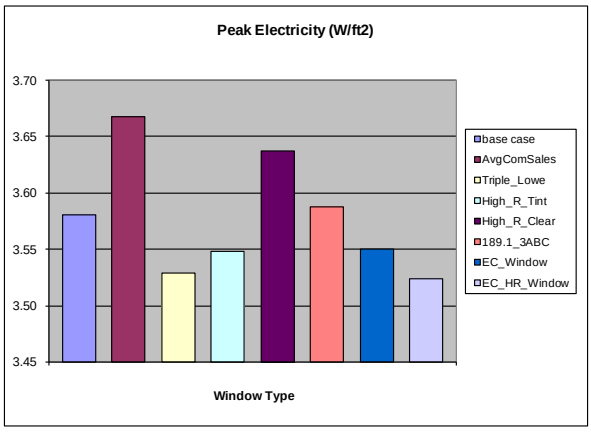
Figure 36 - For Chicago – Shades always off, no daylighting controls

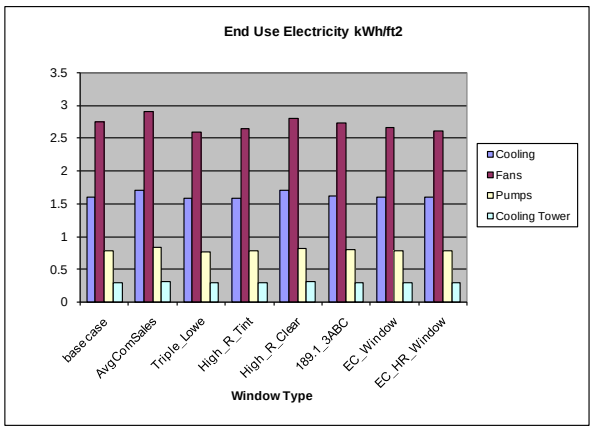


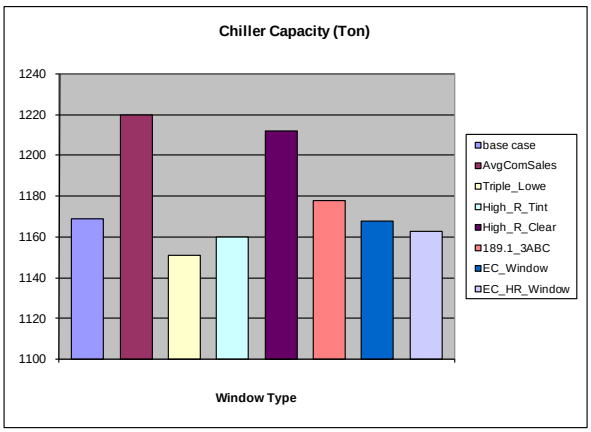


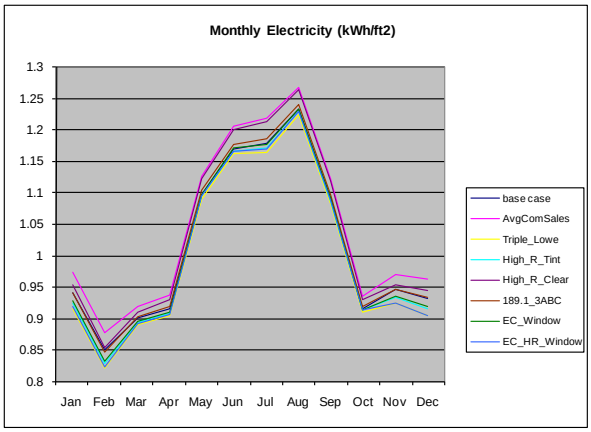


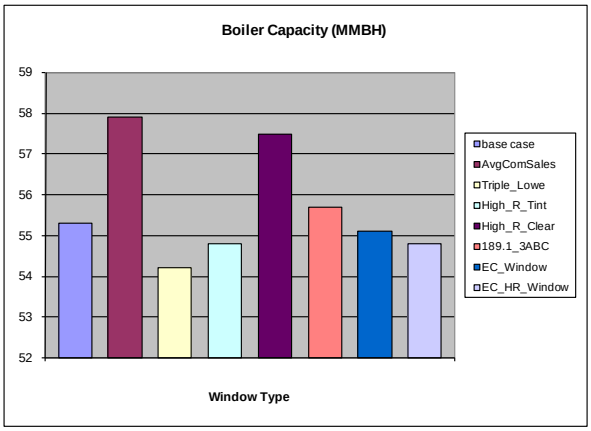


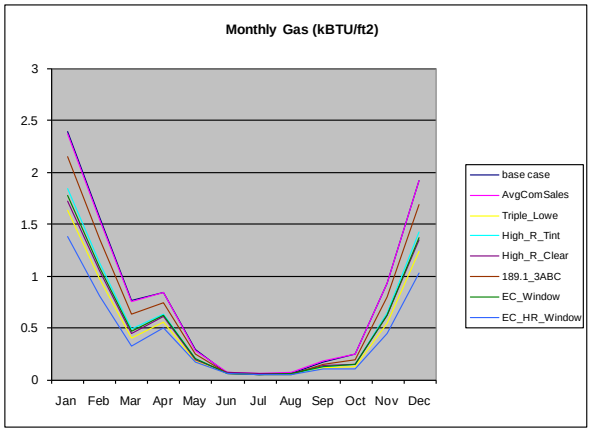



End Use Electricity kWh/ft2
3.5
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1240
1220
1200
1180
1160
1140
1120
1100
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.3
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
59
58
57
56
55
54
53
52
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Gas (kBTU/ft2)
3
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

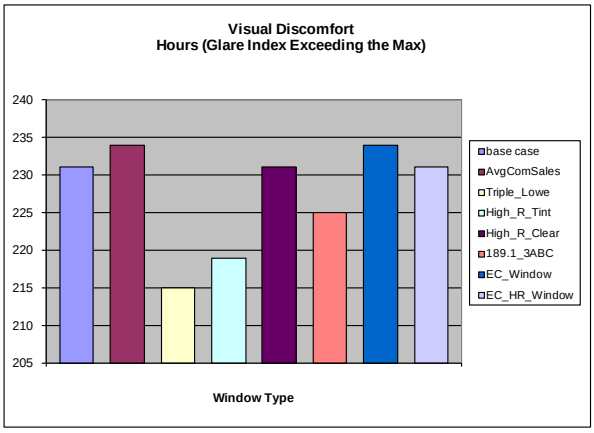
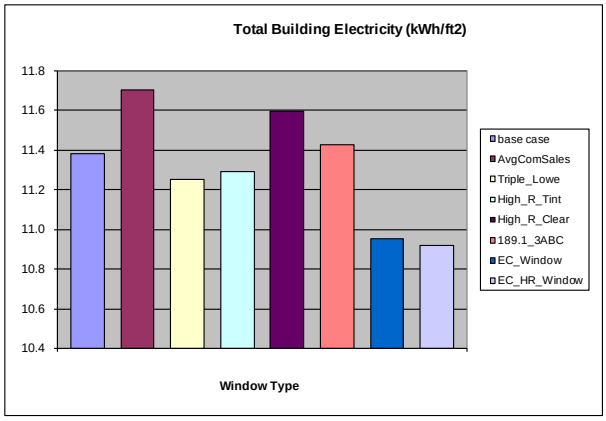
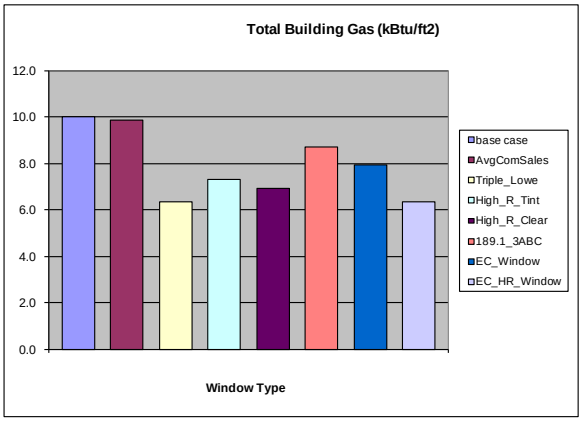
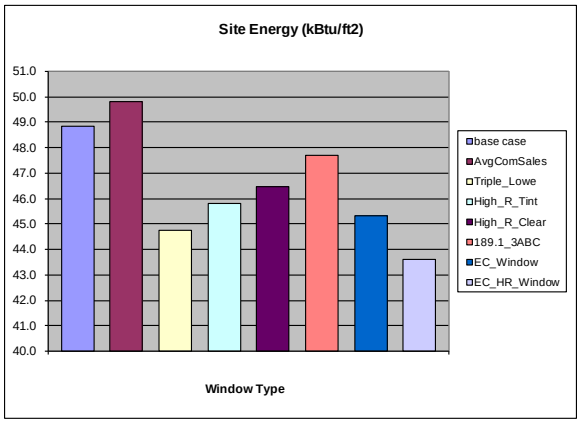
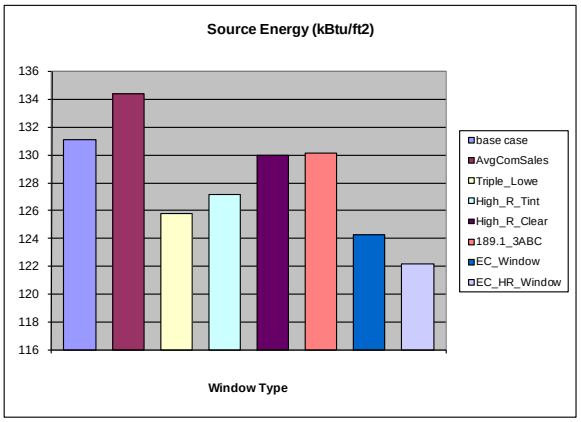

Visual Discomfort
Hours (Glare Index Exceeding the Max)
240
235
230
225
220
215
210
205
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

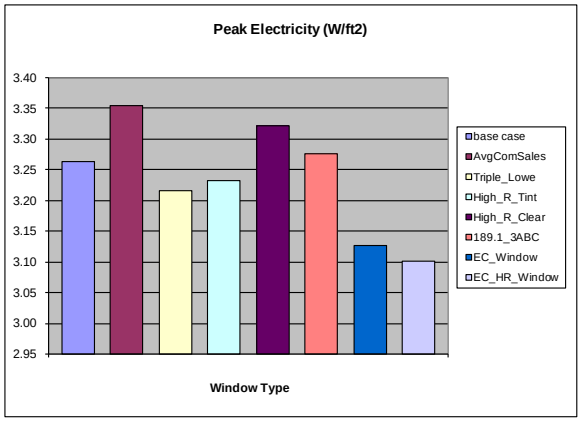
Figure 37 - For Chicago – Shades always off, with daylighting controls

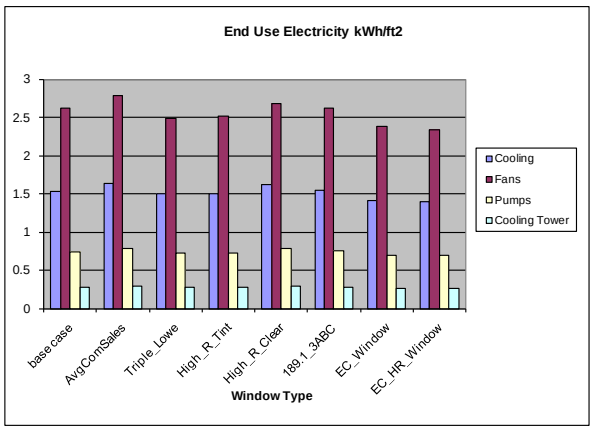


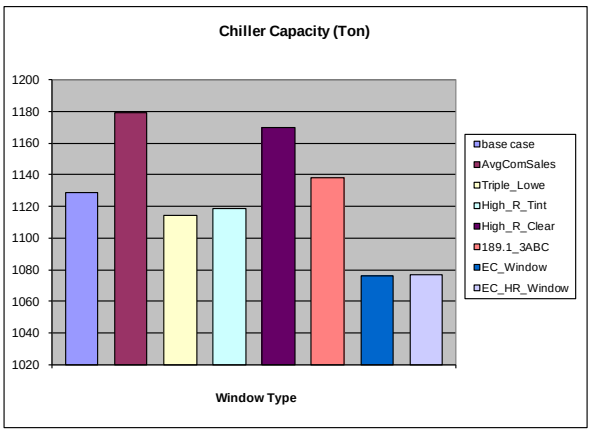


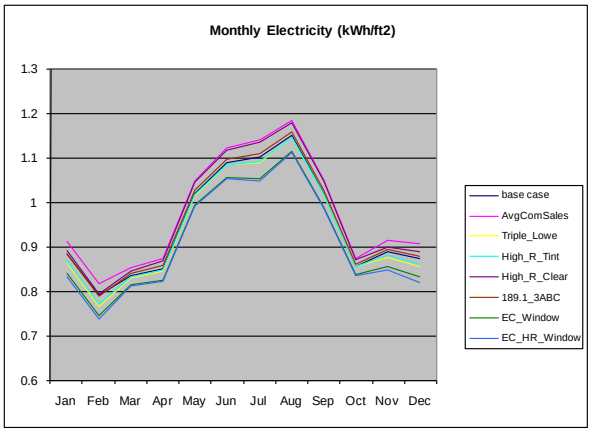


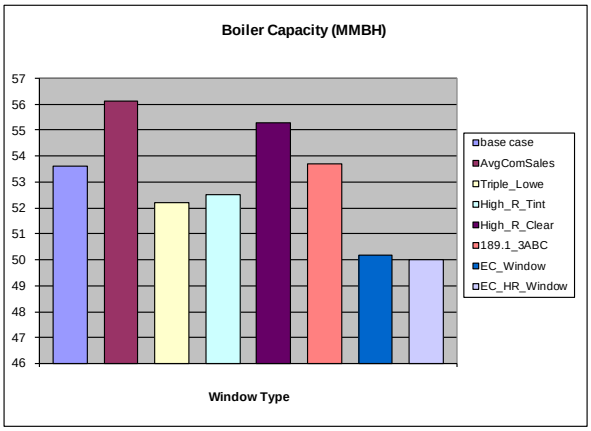


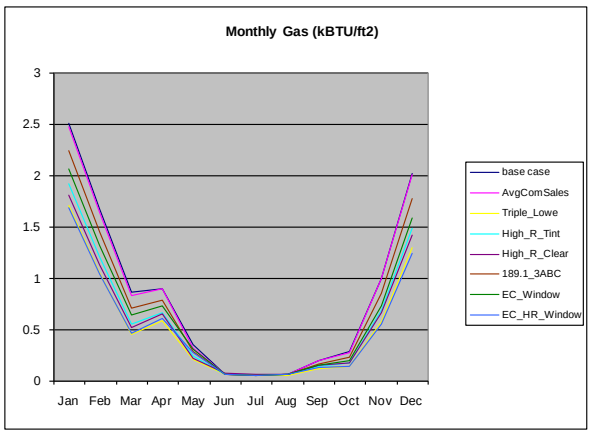



End Use Electricity kWh/ft2
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1200
1180
1160
1140
1120
1100
1080
1060
1040
1020
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
57
56
55
54
53
52
51
50
49
48
47
46
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Gas (kBTU/ft2)
3
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

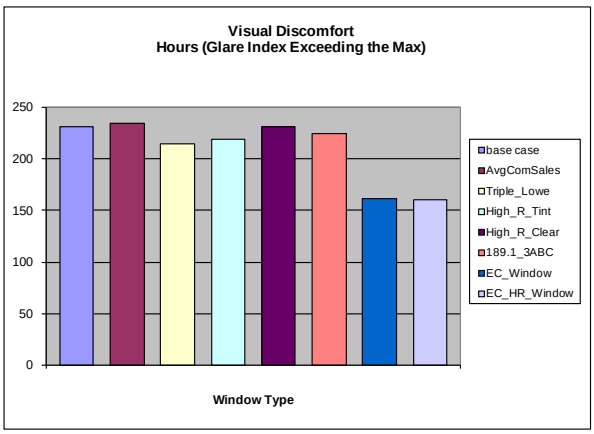
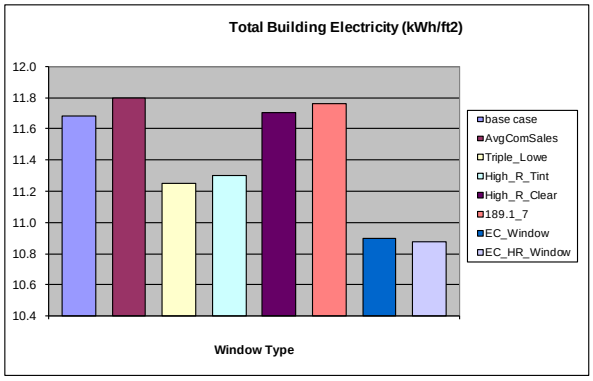
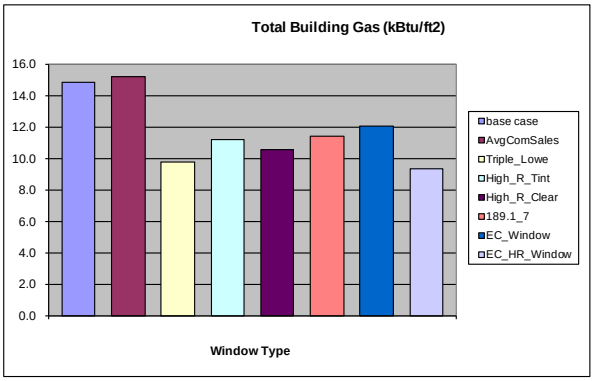
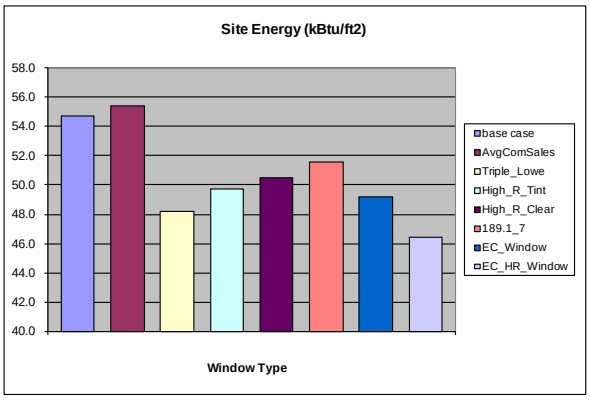
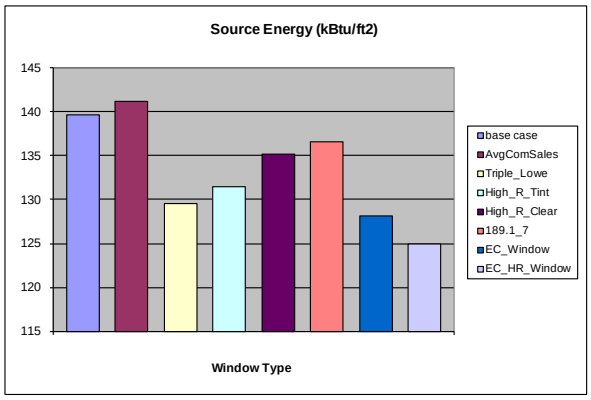

Visual Discomfort
Hours (Glare Index Exceeding the Max)
250
200
150
100
50
0
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

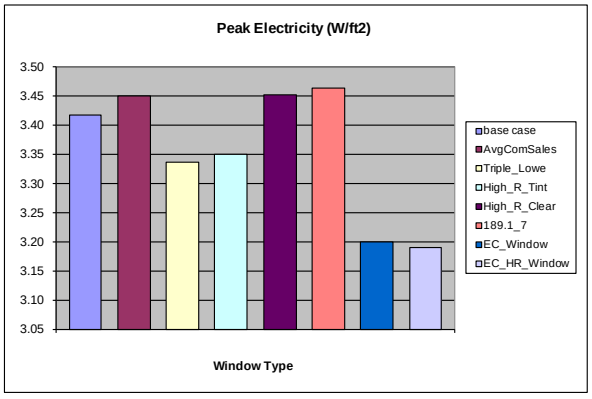
Figure 38 - For Duluth – Shades on if high glare, no daylighting controls

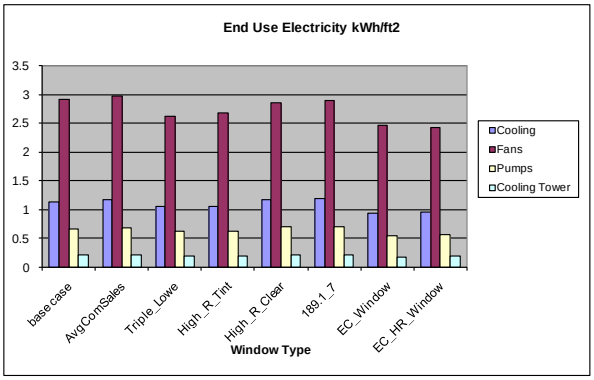


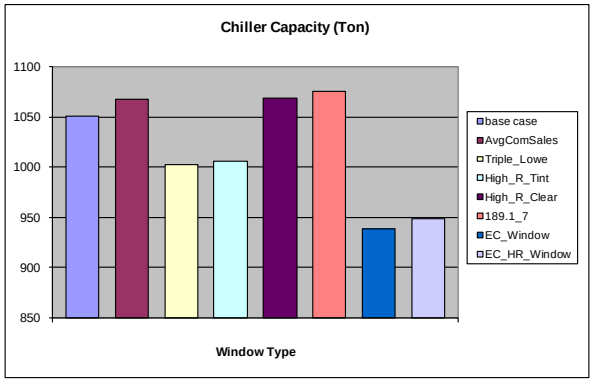


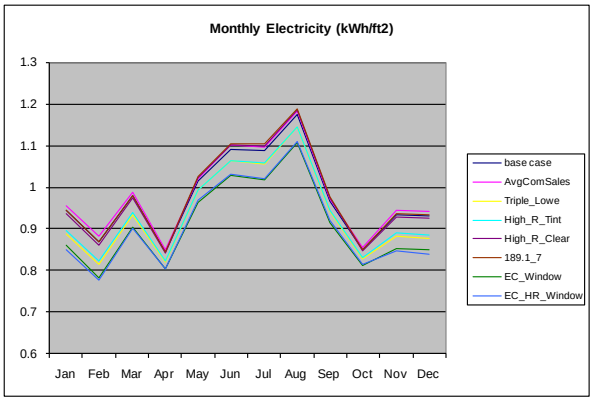


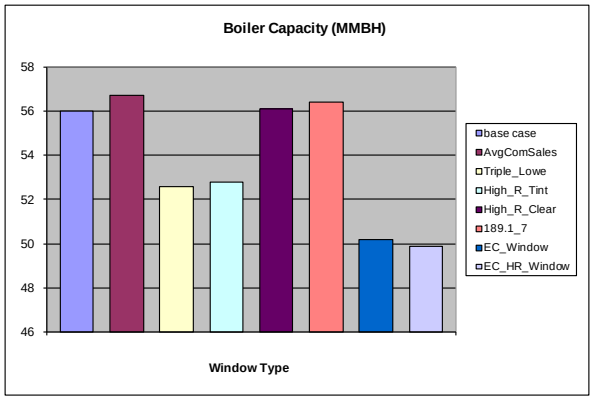





End Use Electricity kWh/ft2
3.5
3
2.5
2
1.5
1
0.5
0
Cooling
Fans
Pumps
Cooling Tower
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_7
EC_Window
EC_HR_Window
Window Type


Chiller Capacity (Ton)
1100
1050
1000
950
900
850
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_7
EC_Window
EC_HR_Window
Window Type


Monthly Electricity (kWh/ft2)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_7
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
58
56
54
52
50
48
46
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_7
EC_Window
EC_HR_Window
Window Type

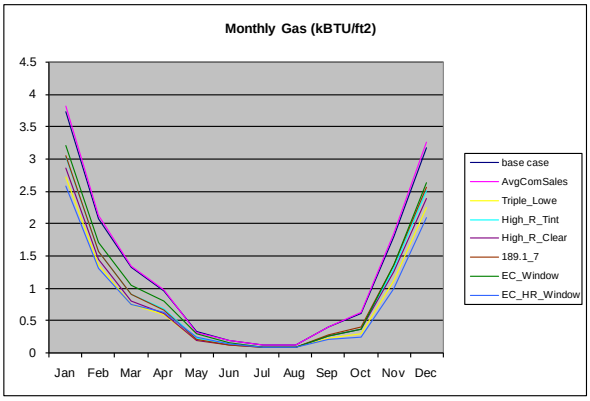
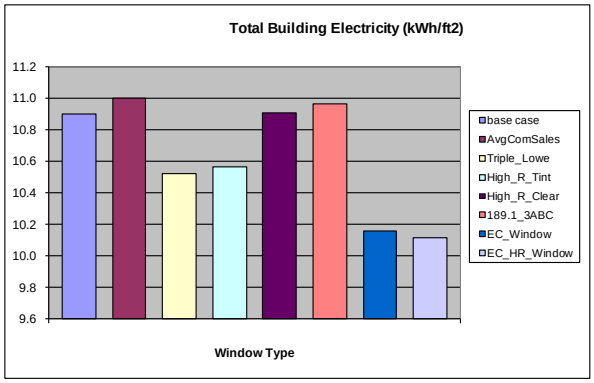
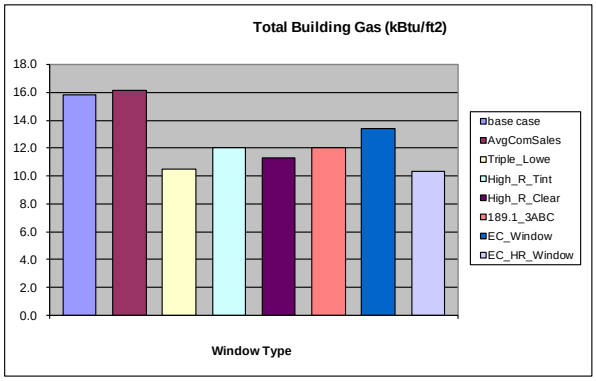
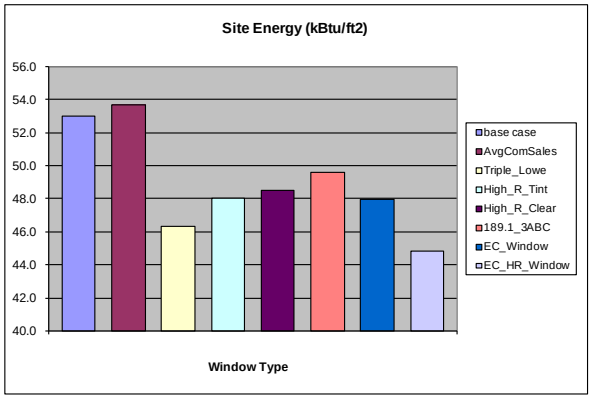
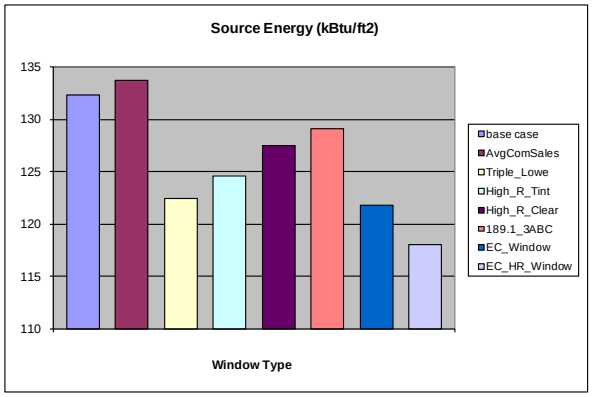

Monthly Gas (kBTU/ft2)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_7
EC_Window
EC_HR_Window

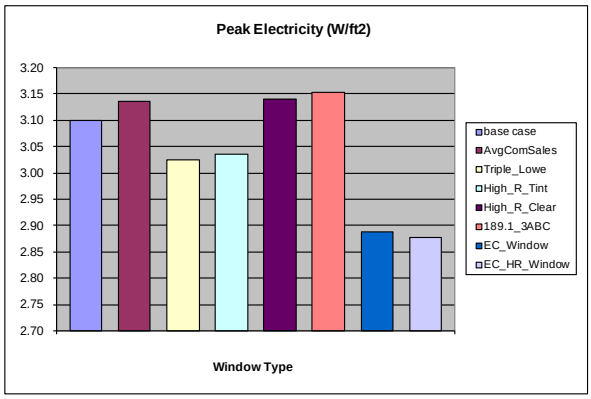
Figure 39 - For Duluth – Shades on if high glare, with daylighting controls

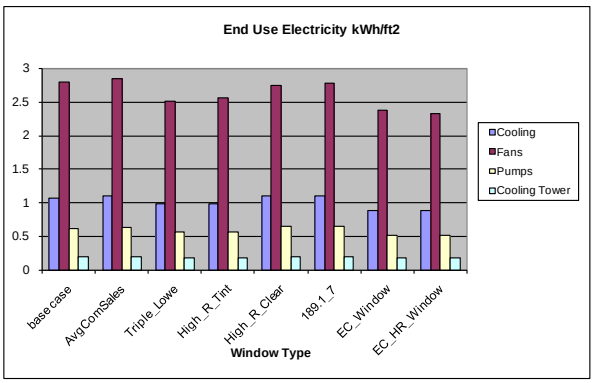


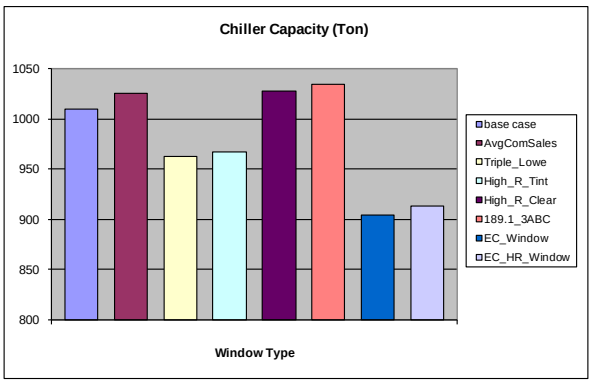


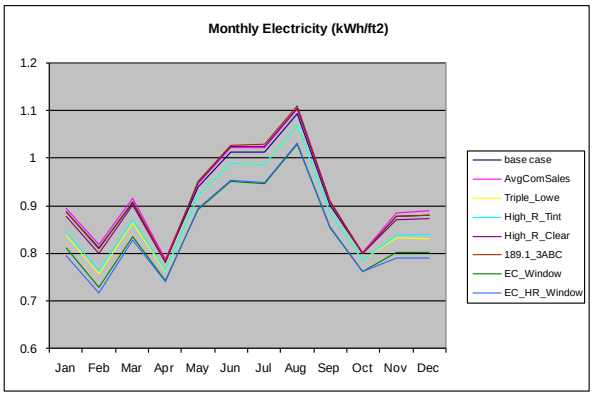


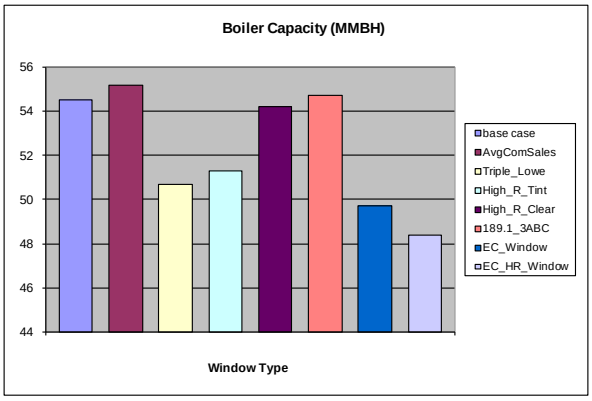





End Use Electricity kWh/ft2
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_7
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1050
1000
950
900
850
800
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.2
1.1
1
0.9
0.8
0.7
0.6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
56
54
52
50
48
46
44
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

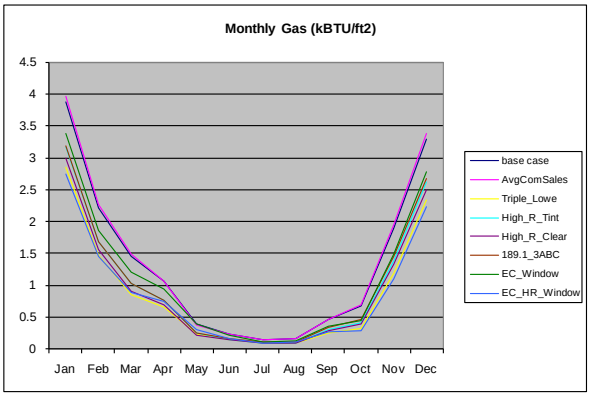
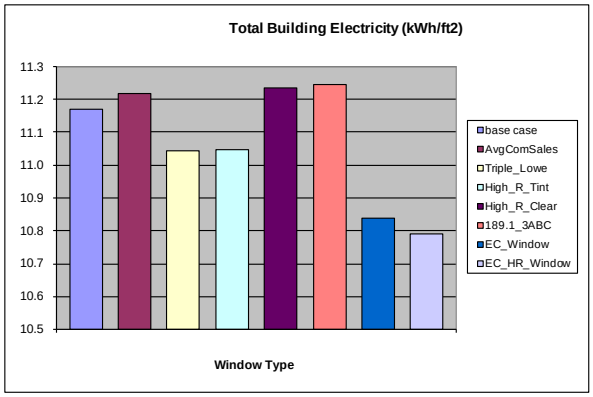
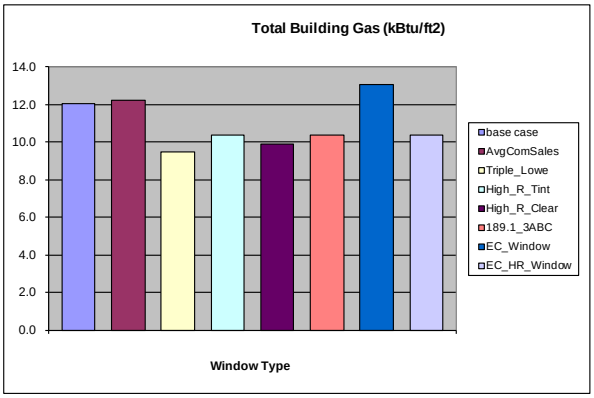
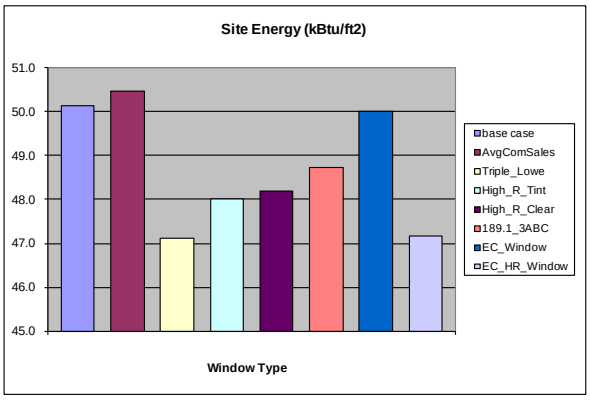
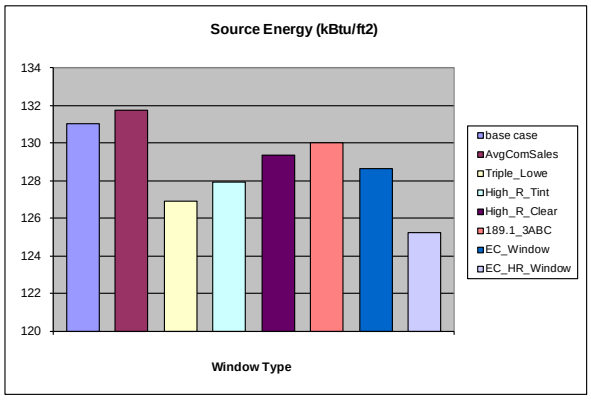

Monthly Gas (kBTU/ft2)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

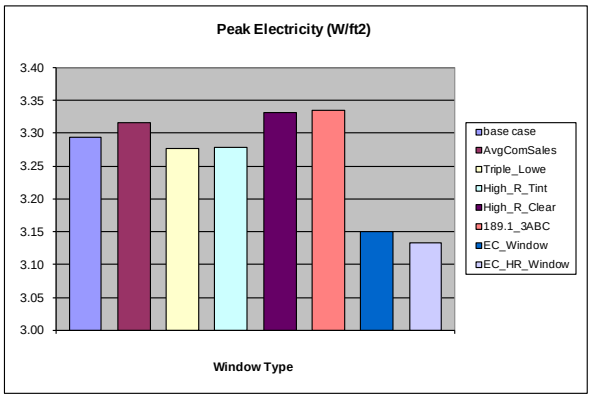
Figure 40 - For Duluth – Shades always on, no daylighting controls

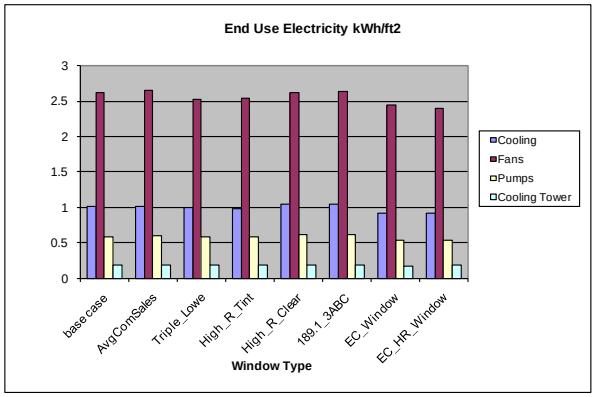


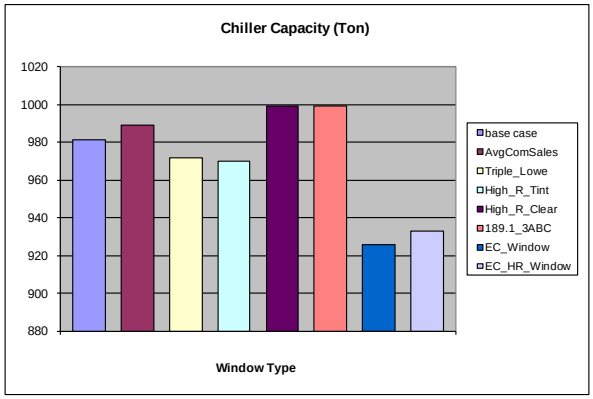


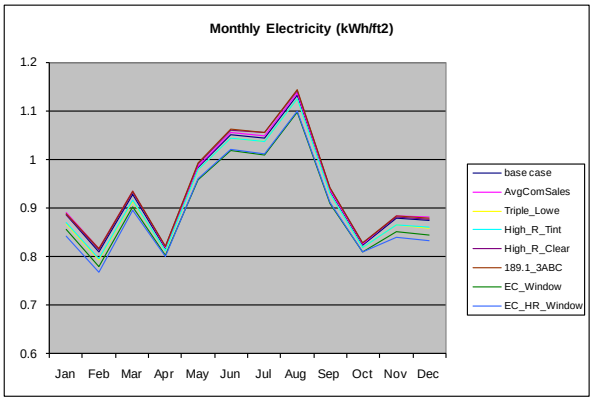


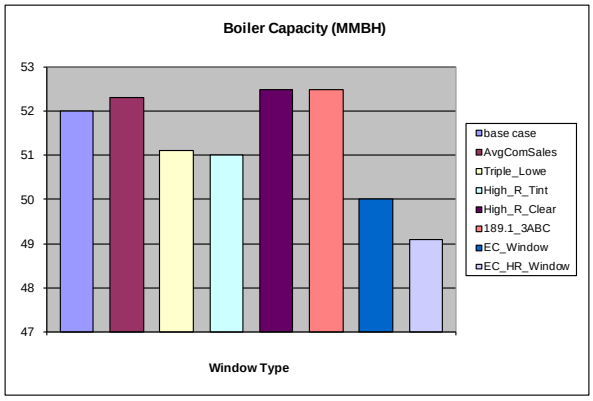





End Use Electricity kWh/ft2
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1020
1000
980
960
940
920
900
880
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.2
1.1
1
0.9
0.8
0.7
0.6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
53
52
51
50
49
48
47
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

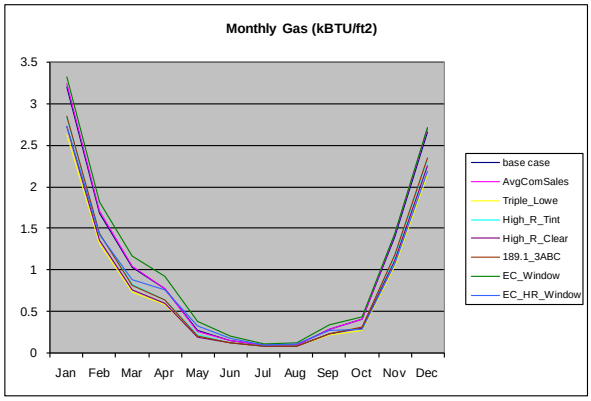
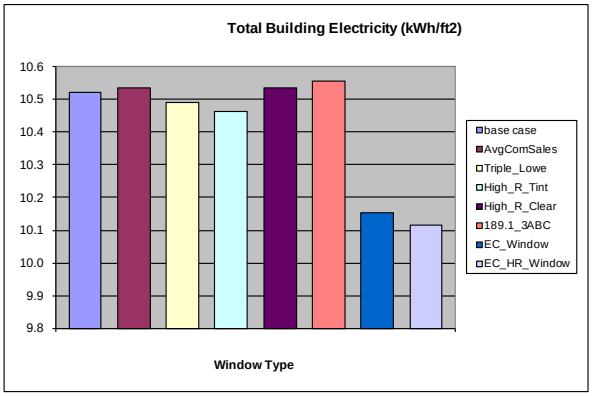
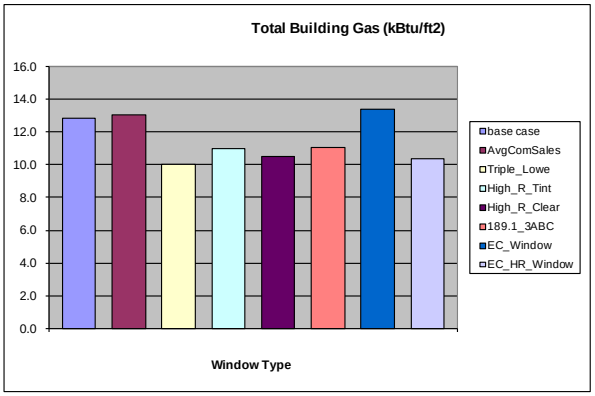
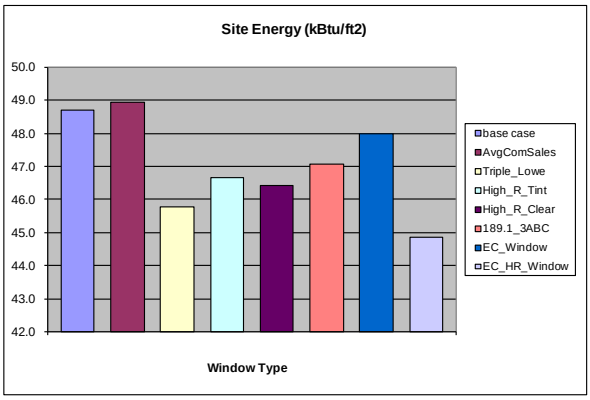
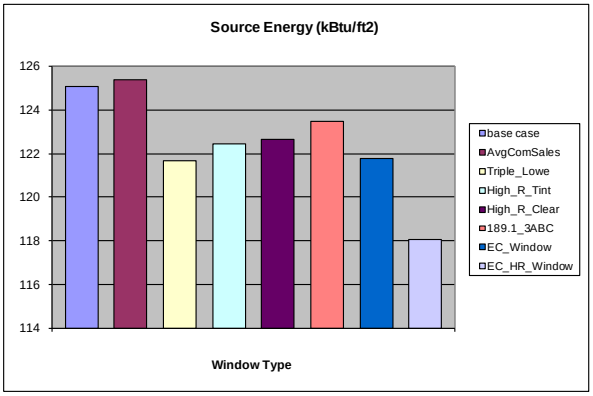

Monthly Gas (kBTU/ft2)
3.5
3
2.5
2
1.5
1
0.5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

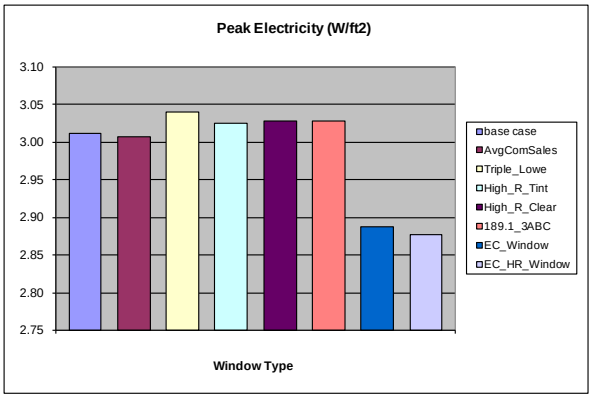
Figure 41 - For Duluth – Shades always on, with daylighting controls

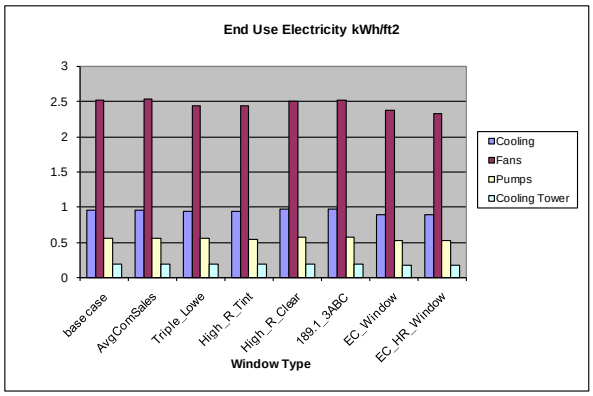


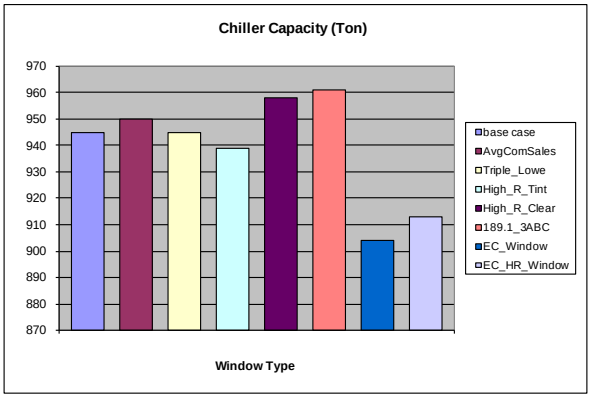


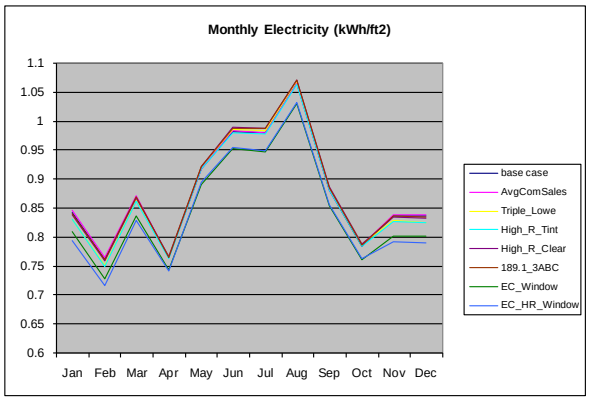


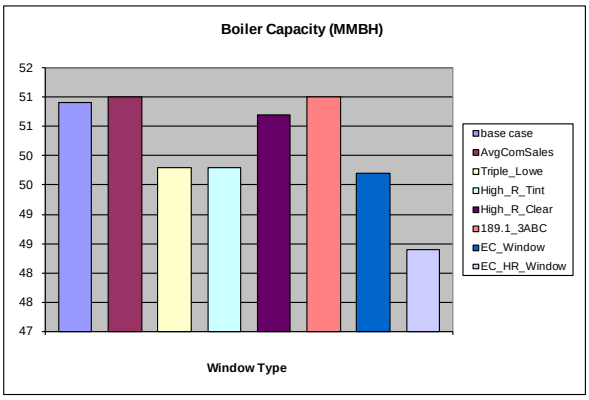





End Use Electricity kWh/ft2
3
2.5
2
1.5
1
0.5
0
Cooling
Fans
Pumps
Cooling Tower
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Chiller Capacity (Ton)
970
960
950
940
930
920
910
900
890
880
870
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Monthly Electricity (kWh/ft2)
1.1
1.05
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
52
51
51
50
50
49
49
48
48
47
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type

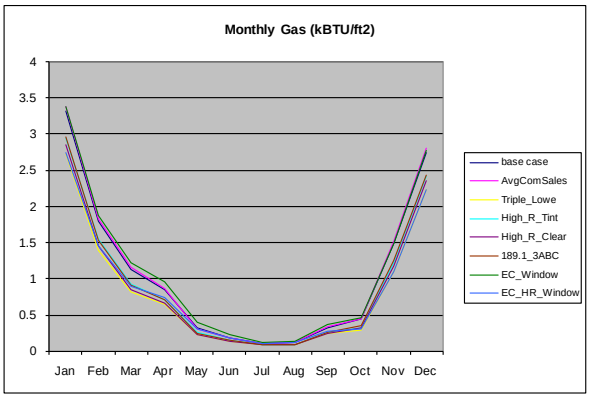
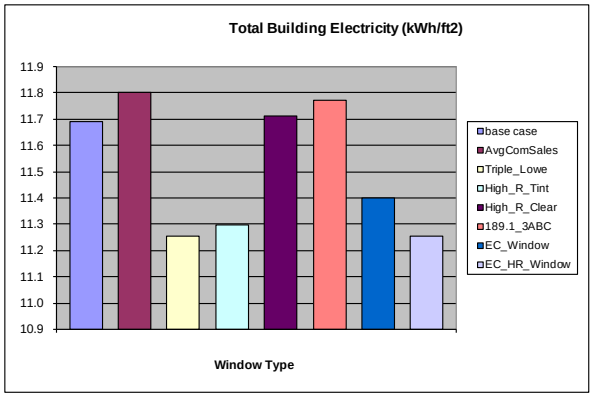
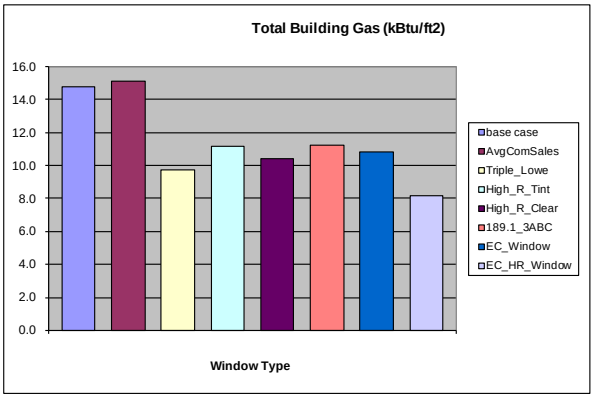
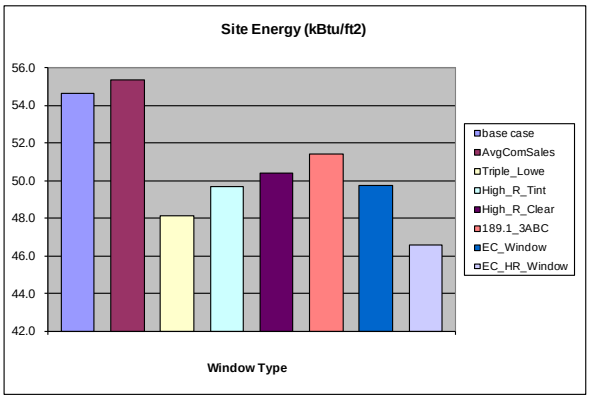
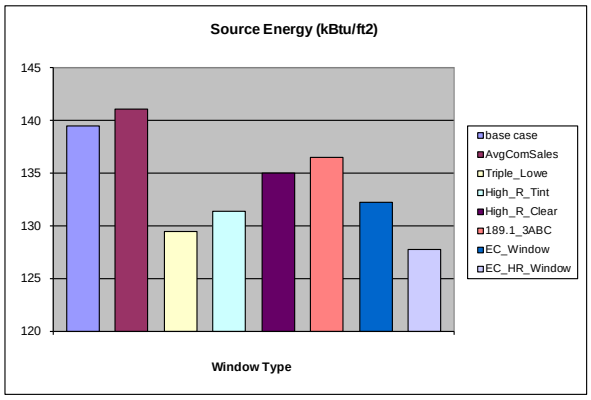

Monthly Gas (kBTU/ft2)
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

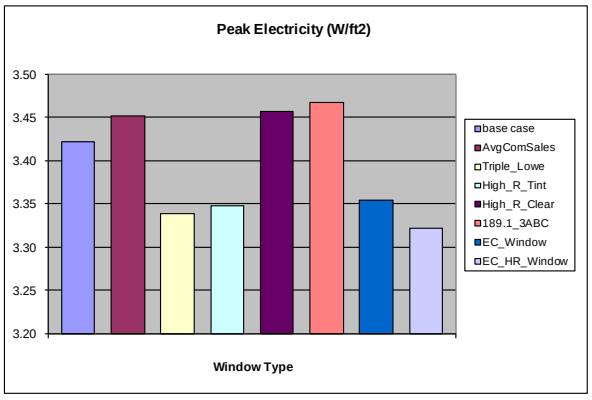
Figure 42 - For Duluth – Shades always off, no daylighting controls

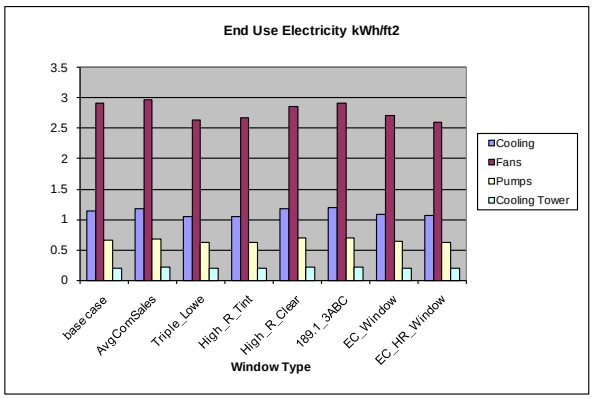


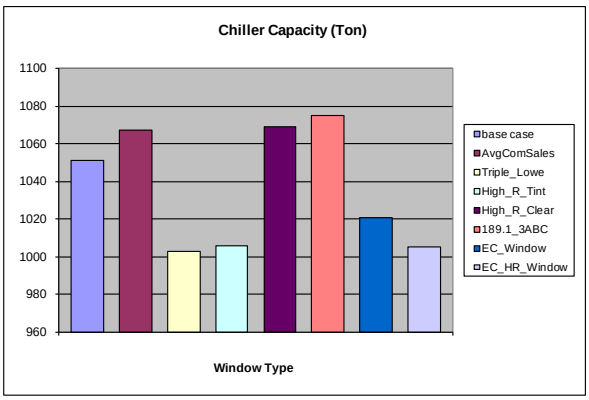


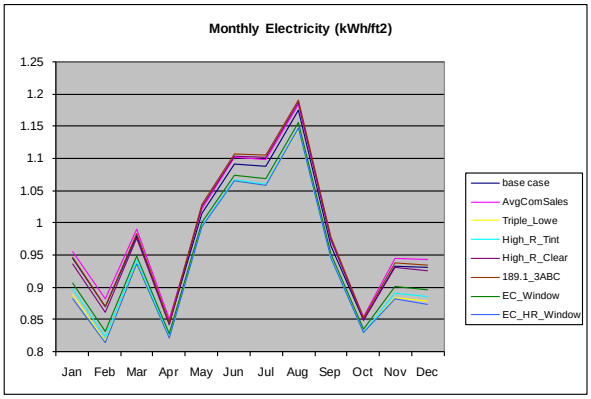


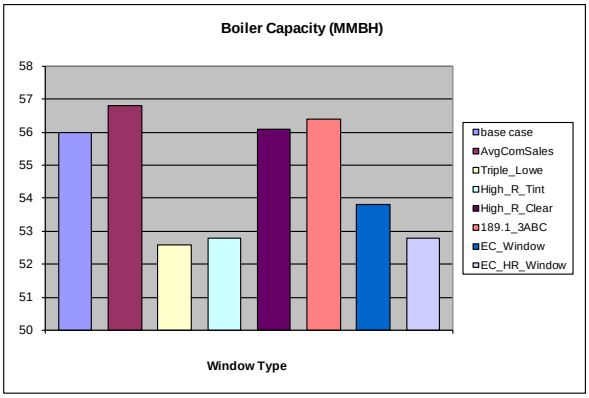


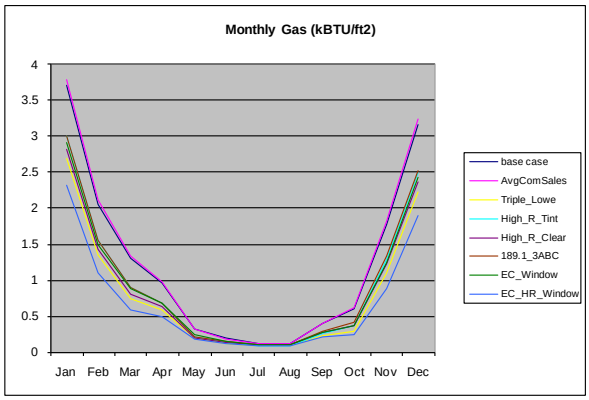



End Use Electricity kWh/ft2
3.5
3
2.5
2
1.5
1
0.5
0
Cooling
Fans
Pumps
Cooling Tower
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Chiller Capacity (Ton)
1100
1080
1060
1040
1020
1000
980
960
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Monthly Electricity (kWh/ft2)
1.25
1.2
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
58
57
56
55
54
53
52
51
50
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type


Monthly Gas (kBTU/ft2)
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

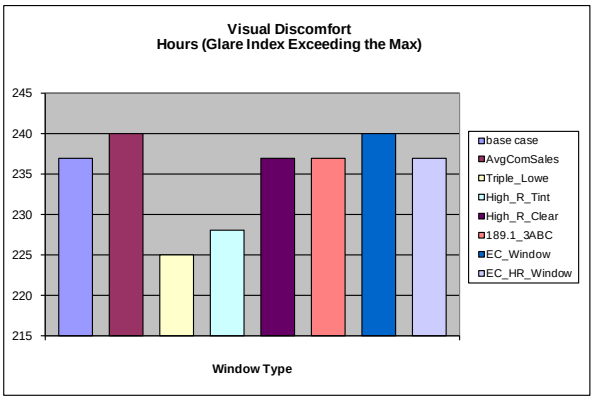
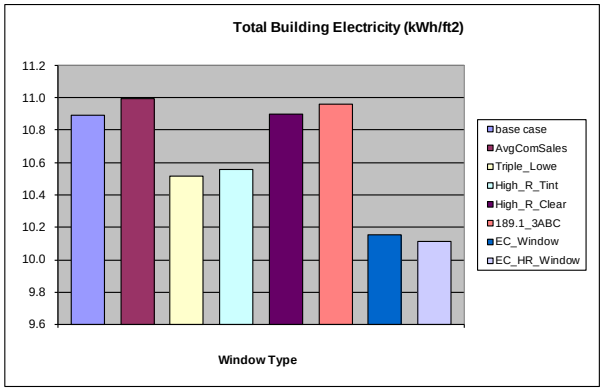
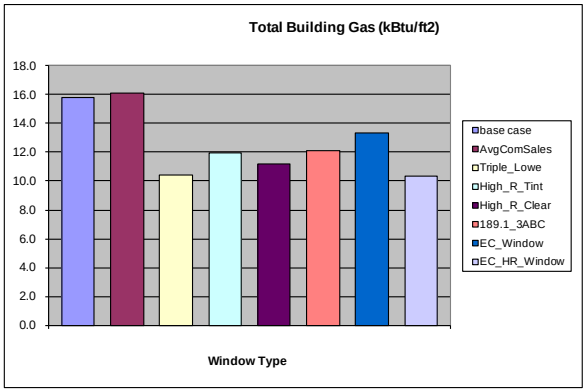
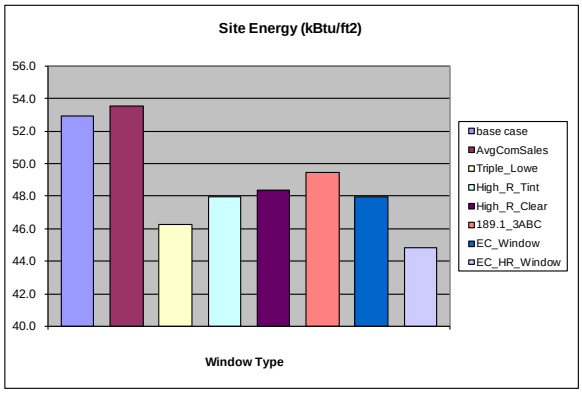
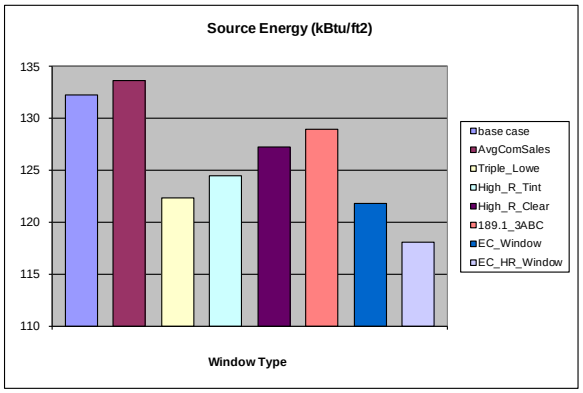

Visual Discomfort
Hours (Glare Index Exceeding the Max)
245
240
235
230
225
220
215
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type

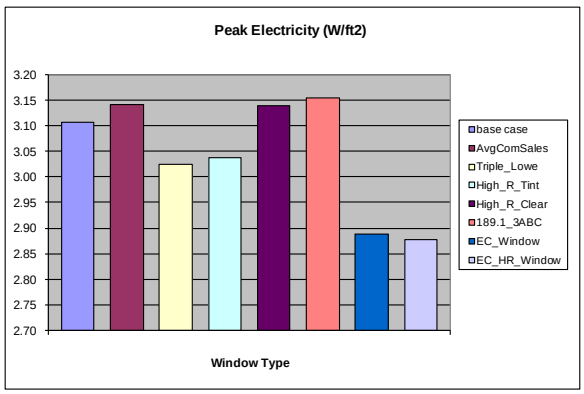
Figure 43 - For Duluth – Shades always off, with daylighting controls

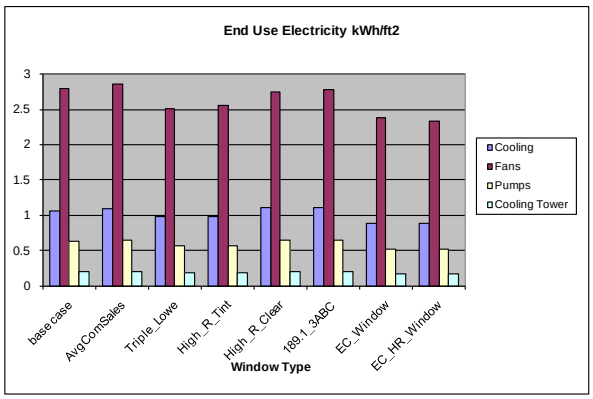


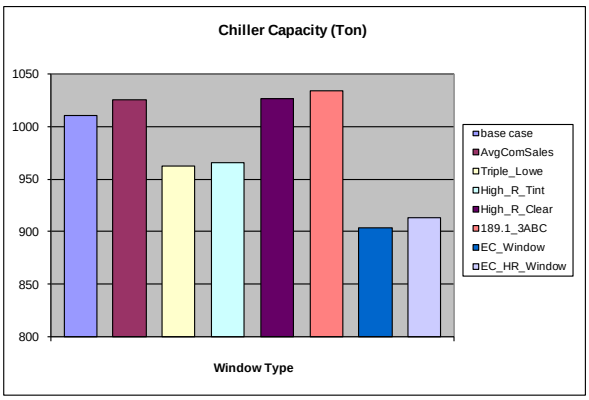


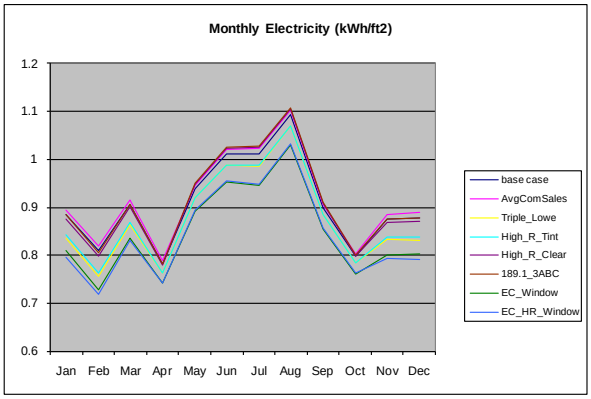


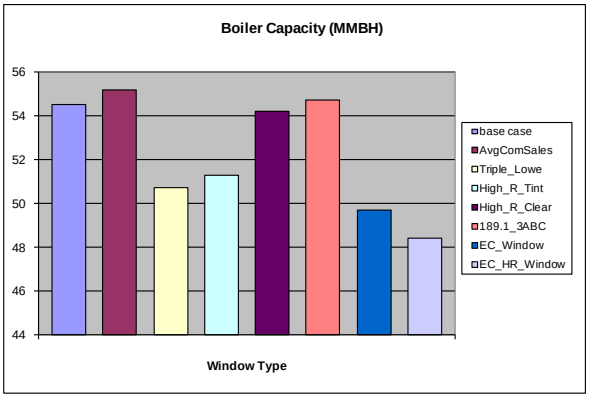


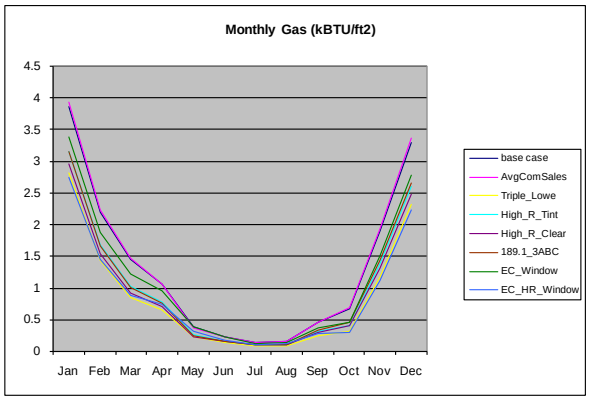



End Use Electricity kWh/ft2
3
2.5
2
1.5
1
0.5
0
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window
Window Type
Cooling
Fans
Pumps
Cooling Tower


Chiller Capacity (Ton)
1050
1000
950
900
850
800
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Electricity (kWh/ft2)
1.2
1.1
1
0.9
0.8
0.7
0.6
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Boiler Capacity (MMBH)
56
54
52
50
48
46
44
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window


Monthly Gas (kBTU/ft2)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

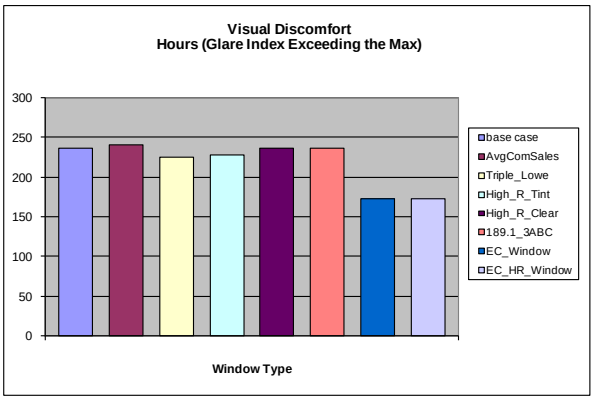

Visual Discomfort
Hours (Glare Index Exceeding the Max)
300
250
200
150
100
50
0
Window Type
base case
AvgComSales
Triple_Lowe
High_R_Tint
High_R_Clear
189.1_3ABC
EC_Window
EC_HR_Window

Table 73 – The Large Office Building Operating Schedules

Schedule	Type	Through	Day of Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Hours_of_operation	on/off	Through 12/31	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ALWAYS_ON	Fraction	Through 12/31	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ALWAYS_OFF	Fraction	Through 12/31	All	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HVACOperationSchd	on/off	Through 12/31	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BLDG_LIGHT_SCH	Fraction	Through 12/31	WD	0.2	0.15	0.1	0.1	0.1	0.2	0.4	0.5	0.4	0.4	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.6	0.8	0.9	0.8	0.6	0.3
			Sat	0.2	0.2	0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.4	0.3	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.6	0.7	0.7	0.7	0.6	0.3
			SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
			WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Sun, Hol, Other	0.3	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.5	0.7	0.8	0.6	0.5	0.3
BLDG_EQUIP_SCH	Fraction	Through 12/31	WD	0.3	0.25	0.2	0.2	0.2	0.3	0.5	0.6	0.5	0.5	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.7	0.9	0.95	0.9	0.7	0.4
			Sat	0.3	0.3	0.2	0.2	0.2	0.2	0.4	0.4	0.5	0.5	0.4	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.7	0.8	0.8	0.8	0.7	0.4
			SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
			WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Sun, Hol, Other	0.4	0.4	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.6	0.8	0.9	0.7	0.6	0.4
BLDG_ELEVATORS	Fraction	Through 12/31	WD, SummerDes	0.4	0.33	0.33	0.33	0.33	0.33	0.42	0.42	0.52	0.52	0.4	0.51	0.51	0.51	0.51	0.51	0.63	0.8	0.86	0.7	0.7	0.7	0.45	0.45
			Sat, WinterDesign	0.44	0.35	0.35	0.35	0.35	0.35	0.4	0.32	0.45	0.45	0.42	0.6	0.65	0.65	0.65	0.65	0.65	0.65	0.75	0.8	0.8	0.75	0.75	0.55	0.55
			Sun, Hol, Other	0.55	0.55	0.43	0.43	0.43	0.43	0.52	0.52	0.65	0.65	0.53	0.6	0.53	0.51	0.5	0.44	0.64	0.62	0.65	0.63	0.63	0.63	0.4	0.4
BLDG_OCC_SCH	Fraction	Through 12/31	WD	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.5	0.5	0.5	0.7	0.7	0.8	0.9	0.9
			SummerDesign	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
			Sat	0.9	0.9	0.9	0.9	0.9	0.9	0.7	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.5	0.6	0.6	0.6	0.7	0.7	0.7
			WinterDesign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Sun, Hol, Other	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.5	0.5	0.5	0.3	0.3	0.2	0.2	0.2	0.3	0.4	0.4	0.6	0.6	0.8	0.8	0.8
BLDG_SWH_SCH	Fraction	Through 12/31	WD, SummerDes	0.2	0.15	0.15	0.15	0.2	0.25	0.5	0.6	0.55	0.45	0.4	0.45	0.4	0.35	0.3	0.3	0.3	0.4	0.55	0.6	0.5	0.55	0.45	0.25
			Sat, WinterDesign	0.2	0.15	0.15	0.15	0.2	0.25	0.4	0.5	0.5	0.5	0.45	0.5	0.5	0.45	0.4	0.4	0.35	0.4	0.55	0.55	0.5	0.55	0.4	0.3
			Sun, Hol, Other	0.25	0.2	0.2	0.2	0.2	0.3	0.5	0.5	0.5	0.55	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.4	0.5	0.5	0.4	0.5	0.4	0.2
ACTIVITY_SCH	Any Number	Through 12/31	All	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
WORK_EFF_SCH	Fraction	Through 12/31	All	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AIR_VELO_SCH	Any Number	Through 12/31	All	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
CLOTHING_SCH	Any Number	Through 04/30	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Through 09/30	All	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		Through 12/31	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
INFIL_SCH	fraction	Through 12/31	All	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INFIL_HALF_ON_SCH	fraction	Through 12/31	All	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
SHADING_SCH	Any Number	Through 12/31	All	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PlantOnSched	On/Off	Through 12/31	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FAN_SCH	Fraction	Through 12/31	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ReheatCoilAvailSched	Fraction	Through 12/31	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CoolingCoilAvailSched	Fraction	Through 12/31	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HTGSETP_SCH	Temperature	Through 12/31	All	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
HTGSETP_SCH_KEYCARD	Temperature	Through 12/31	SummerDesign, V	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
			Other	21	21	21	21	21	21	21	20	20	20	19	19	19	19	19	19	20	20	20	21	21	21	21	21
CLGSETP_SCH	Temperature	Through 12/31	All	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
CLGSETP_SCH_KEYCARD	Temperature	Through 12/31	SummerDesign, V	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
			Other	24	24	24	24	24	24	24	25	25	25	26	26	26	26	26	26	25	25	25	24	24	24	24	24
Humidity Setpoint Schedule	Humidity	Through 12/31	WD, SummerDes	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
			Sat, WinterDesign	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
			Sun, Hol, Other	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
MinOA_MotorizedDamper_Sched	Fraction	Through 12/31	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MinOA_Sched	Fraction	Through 12/31	All	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dual Zone Control Type Sched	Control Type	Through 12/31	All	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Seasonal-Reset-Supply-Air-Temp	Temperature	Through 3/31	All	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
		Through 9/30	All	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
		Through 12/31	All	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
CW-Loop-Temp-Schedule	Temperature	Through 12/31	All	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
HW-Loop-Temp-Schedule	Temperature	Through 12/31	All	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
Heating-Supply-Air-Temp-Sch	Temperature	Through 12/31	All	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Laundry_Flr_1 sub cat Latent frac	Fraction	Through 12/31	All	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05